

Example 2a

June 17, 2020

1 Example 2a: Double Well - Training of DeepCalib

Example code to train DeepCalib to determine the parameters of a double trap.

DeepCalib 1.0 Enhanced force-field calibration via machine learning version 1.0 - 27 April 2020
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1.1 1. INIZIALIZATION

```
In [1]: import DeepCalib
```

1.2 2. DEFINE TRAJECTORY SIMULATION

Here the function that simulates the motion of the Brownian particle in the force field under consideration is defined. Specifically, in this case, we consider a Brownian particle in a double well trap, and the motion of the particle depends on two target parameters: the equilibrium distance L and the potential energy barrier height H .

This file is used to reproduce results that are shown in Fig.3 and generate the pretrained network "Network_Example_2a.h5" that is going to be needed to execute Example 2b.

Comments: 1. The function that simulates the trajectories must be called `simulate_trajectory`.
2. Lambda functions `scale_inputs`, `rescale_inputs`, `scale_targets`, and `rescale_targets` must also be defined. For the best performance of the learning, the rescaling of both the inputs and targets should lead to values of order 1.

```
In [2]: ### Physical parameters
        from math import pi
        import numpy as np
        from scipy.constants import Boltzmann as kB
        R = 1e-7 # Radius of the Brownian particle [m]
        eta = 0.001 # Viscosity of the medium [kg m^-1 s^-1]
        T = 300 # Temperature [K]
        L0 = 2e-6 # Reference distance from middle to one minimum [m]
        H0 = kB*300 # Barrier height [Joule]
        gamma0 = 3 * 6 * pi * eta * R # Reference friction coefficient [kg s^-1]

        ### Simulation parameters
        N = 1000 # Number of samples of the trajectory
        Dt = 5e-2 # Timestep
```

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dt = 2e-3
oversampling = int(Dt/dt) # Simulation oversampling
offset = 1000             # Number of equilibration points

### Define functions to scale and rescale inputs
scale_inputs = lambda x: x * 1e+6 # Scales input trajectory to order
rescale_inputs = lambda scaled_x: scaled_x * 1e-6 # Rescales input trajectory to phys

### Define function to scale and rescale targets
from numpy import log10

scale_targets = lambda L, H: [L/L0 -1,
                              np.log(H / H0)] # Scales targets to
rescale_targets = lambda scaled_L, scaled_H: [(1 + scaled_L)*L0*1e6,
                                              np.exp(scaled_H) * H0/kB/300] # Inverse of

### Define the simulate_trajectory function

def simulate_trajectory(batch_size=32,
                        T=T,
                        L0=L0,
                        H0=H0,
                        gamma0=gamma0,
                        N=N,
                        dt=dt,
                        oversampling=oversampling,
                        offset=offset,
                        scale_inputs=scale_inputs,
                        scale_targets=scale_targets):

    """Simulates a Brownian particle in a double trap

    Inputs:

    T:            temperature of the environment
    L0:           center of the equilibrium distance range
    H0:           center of the barrier height range
    gamma0:       friction coefficient
    N:            number of trajectory data points
    Dt:           measurement period
    oversampling: oversampling from the simulation time step (to calculate dt)
    offset:       steps of the simulation before starting to save the trajectory
    scale_inputs: inputs scale function for the network, to normalize it comparable to
    scale_targets: targets scale function for the network, to normalize it comparable to

```

Outputs:

inputs: the inputs for the network, these are trajectories that have the following f

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    inputs.names:          names of the input trajectory variables ('x', 'y' etc)
    inputs.values:         values of the inputs in SI units
    inputs.scalings:       short description of the scaling function for the inp
    inputs.scaled_values:  scaled values of the inputs to be passed to the netwo

```

targets: the expected ground truth measurements for the trajectory that have followi

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    targets.names:         names of the targets to be measures ('k' etc)
    targets.values:        values of the ground truth targets in SI units
    targets.scalings:      short description of the scaling function for the ta
    targets.scaled_values: scaled values of the ground truth targets to be pass

```

"""

```

import numpy as np
from scipy.constants import Boltzmann as kB
from math import pi
from math import sqrt
from numpy.random import randn as gauss
from numpy.random import rand as uniform

### Randomize trajectory parameters
L = L0 * (uniform(batch_size)+.5)
H = H0 * 10**(uniform(batch_size)*1.75 - .75)
gamma = gamma0 * (uniform(batch_size)*.1 + .95)

### Simulate
x = np.zeros((batch_size, N))
k0 = 4*H/L**2
k1 = 4*H/L**4
D = kB * T / gamma
C1 = +k0 / gamma * dt
C2 = -k1 / gamma * dt
C3 = np.sqrt(2 * D * dt)

X = x[:,0]
n = 0

for t in range(offset):                                # Offset

    X = X + C1 * X + C2 * X**3 + C3 * gauss(batch_size)

for t in range(N * oversampling):                        # Simulation
    X = X + C1 * X + C2 * X**3 + C3 * gauss(batch_size)
    if t % oversampling == 0:
        x[:,n] = X

```

```

        n += 1

    # Normalize trajectory and targets
    inputs = DeepCalib.trajectory(
        names=['x'],
        values=x,
        scalings=['x * 1e-6'],
        scaled_values=scale_inputs(x))

    targets = DeepCalib.targets(
        names=['Distance [ $\mu\text{m}$ ]', 'Barrier Height [ $k_B T$ ']],
        values=np.swapaxes([L*1e6, H/kB/300],0,1),
        scalings=['L/L0 -1', 'log(H/H0)'],
        scaled_values=np.swapaxes(scale_targets(*[L, H]),0,1))

    return inputs, targets

```

1.3 3. CHECK TRAJECTORY SIMULATION

Checks the results of the function to simulate the trajectories by plotting some examples in rescaled units.

Have a look at the trajectories and check if they match your system, and keep an eye on different trajectories and make sure your scaled units vary in the order of 1, i.e, neither too small (0.01 or smaller) nor too large (100 or larger)

The parameter `number_of_images_to_show` determines the number of trajectories that are plotted.

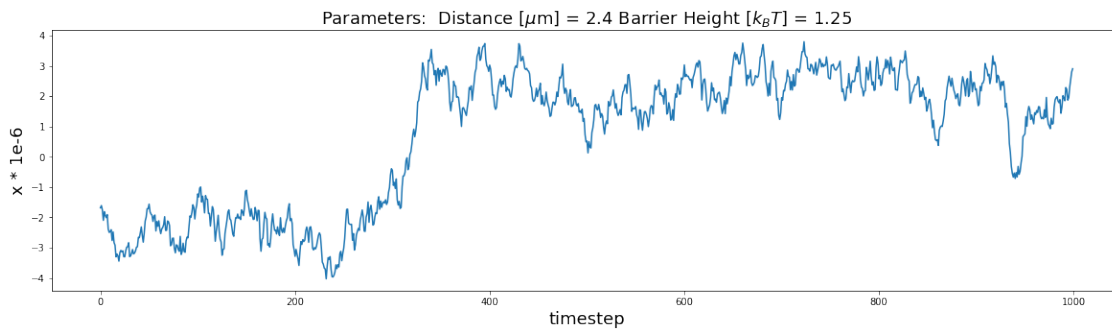
In [3]: *### Show some examples of simulated trajectories*

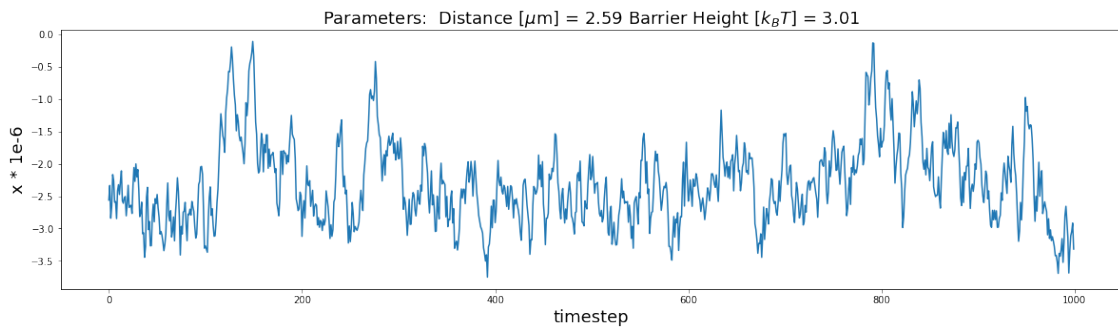
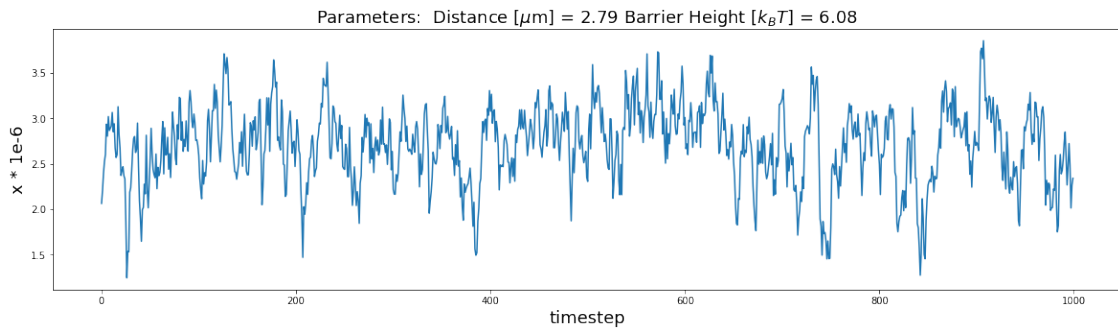
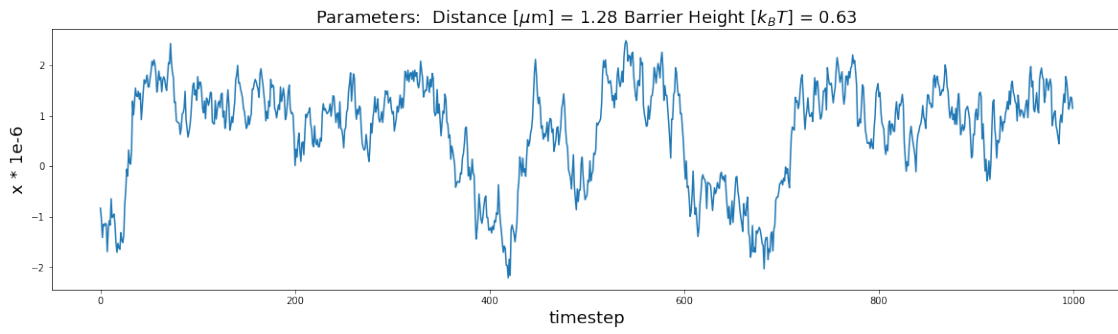
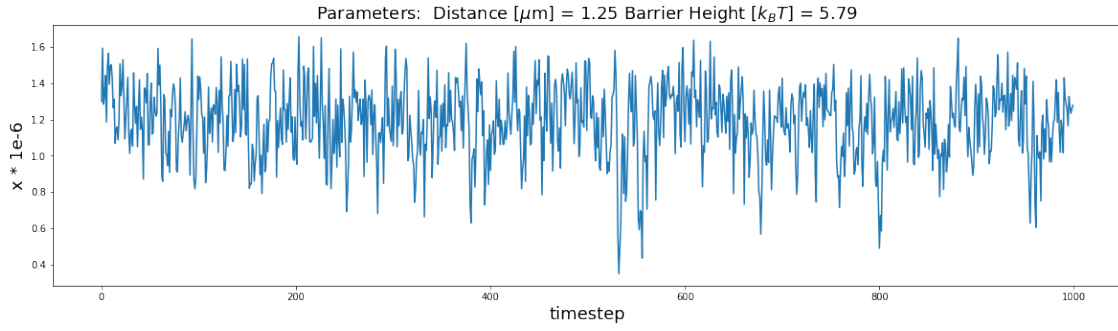
```

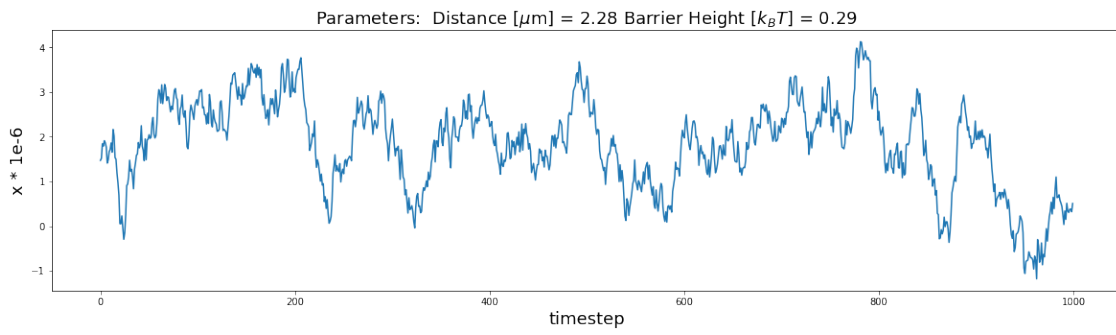
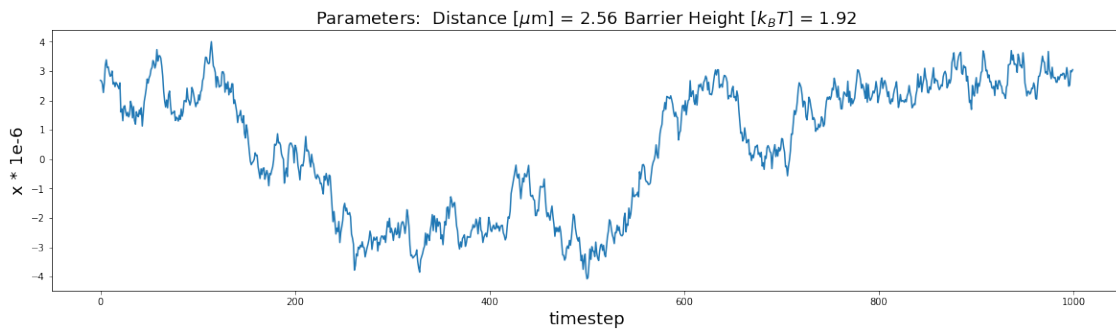
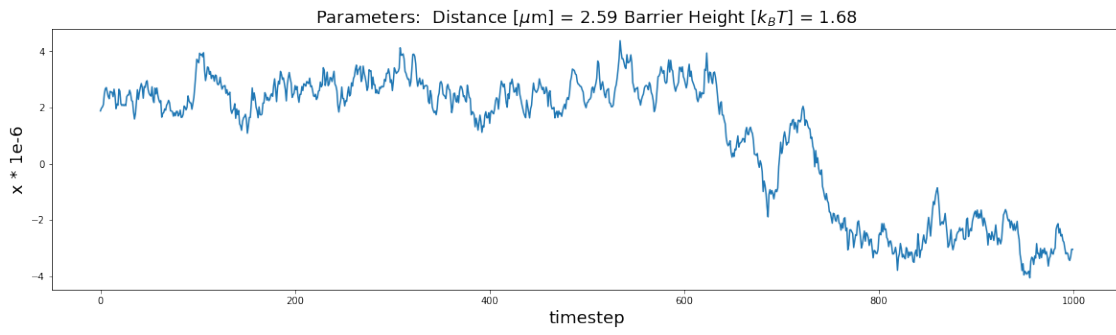
number_of_trajectories_to_show = 10

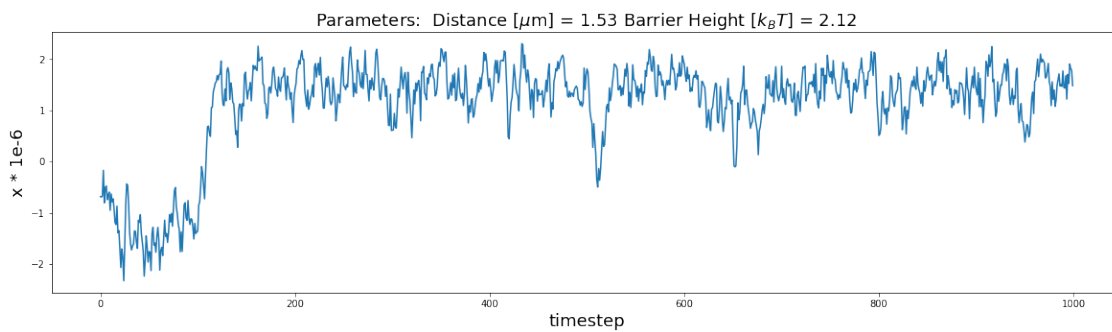
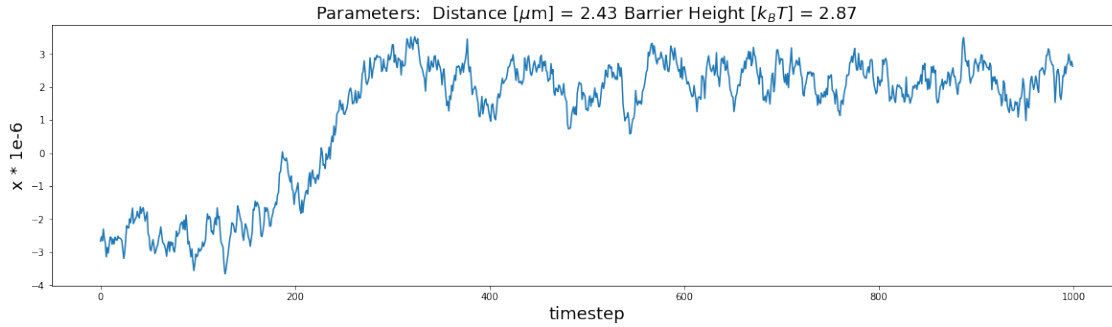
%matplotlib inline
DeepCalib.plot_sample_trajectories(simulate_trajectory, number_of_trajectories_to_show)

```









1.4 4. CREATE AND COMPILE DEEP LEARNING NETWORK

The parameters of the deep learning network are defined and the network created. The summary of the network is printed where the output shape and number of parameters for each layer can be visualized.

Comments: 1. The parameter `input_shape` determines the shape of the input sequence, given by the number of time-steps times the number of samples in each input sequence. Make sure your input shape dimensions match the length of the input trajectory, in this example $2 \times 500 = 1000$. 2. The parameter `conv_layers_dimensions` determines the number and size of LSTM layers. 3. The parameter `number_of_outputs` determines the number of outputs, i.e. the number of force field parameters to be estimated.

```
In [6]: ### Define parameters of the deep learning network
        input_shape = (20, 50)
        lstm_layers_dimensions = (1000, 250, 50)
        number_of_outputs = 2

        ### Create deep learning network
        network = DeepCalib.create_deep_learning_network(input_shape, lstm_layers_dimensions, nu

        ### Print deep learning network summary
        network.summary()
```

Layer (type)	Output Shape	Param #
lstm_1 (LSTM)	(None, 20, 1000)	4204000
lstm_2 (LSTM)	(None, 20, 250)	1251000
lstm_3 (LSTM)	(None, 50)	60200
output (Dense)	(None, 2)	102
Total params: 5,515,302		
Trainable params: 5,515,302		
Non-trainable params: 0		

1.5 5. TRAIN DEEP LEARNING NETWORK

The parameters for the training of the deep learning network are defined and the network is trained. The sample size, iteration number, MSE, MAE and the time of each iteration is printed.

Comments: 1. The parameter sample_sizes determines the sizes of the batches of trajectories used in the training. 2. The parameter iteration_numbers determines the numbers of batches used in the training. 3. The parameter verbose determines the frequency of the update messages. It can be either a boolean value (True/False) or a number between 0 and 1.

```
In [7]: ## Define parameters of the training
        sample_sizes = (32, 128, 512, 2048)
        iteration_numbers = (1001, 1001, 2001, 4001)

        verbose = .1

        ### Training
        training_history = DeepCalib.train_deep_learning_network(network, simulate_trajectory, s
```

Sample size	32	iteration number	1	MSE	0.8478	MAE	0.6539	Time	5084.29026
Sample size	32	iteration number	11	MSE	0.8566	MAE	0.6822	Time	267.284870
Sample size	32	iteration number	21	MSE	0.5012	MAE	0.5232	Time	262.298822
Sample size	32	iteration number	31	MSE	0.4282	MAE	0.4533	Time	262.298822
Sample size	32	iteration number	41	MSE	0.5193	MAE	0.5206	Time	259.306908
Sample size	32	iteration number	51	MSE	0.5139	MAE	0.5090	Time	271.273375
Sample size	32	iteration number	61	MSE	0.3357	MAE	0.3905	Time	266.233444
Sample size	32	iteration number	71	MSE	0.3570	MAE	0.4207	Time	264.293671
Sample size	32	iteration number	81	MSE	0.4015	MAE	0.4356	Time	263.295889
Sample size	32	iteration number	91	MSE	0.3715	MAE	0.4166	Time	266.288280
Sample size	32	iteration number	101	MSE	0.3916	MAE	0.4023	Time	264.295578
Sample size	32	iteration number	111	MSE	0.2320	MAE	0.3210	Time	265.291214
Sample size	32	iteration number	121	MSE	0.2963	MAE	0.3487	Time	262.299299

Sample size	32	iteration number	131	MSE	0.2323	MAE	0.3475	Time	265.290737
Sample size	32	iteration number	141	MSE	0.3005	MAE	0.3925	Time	262.994766
Sample size	32	iteration number	151	MSE	0.2813	MAE	0.3508	Time	294.178009
Sample size	32	iteration number	161	MSE	0.2484	MAE	0.3101	Time	261.141539
Sample size	32	iteration number	171	MSE	0.2153	MAE	0.3315	Time	259.305239
Sample size	32	iteration number	181	MSE	0.1275	MAE	0.2412	Time	262.352943
Sample size	32	iteration number	191	MSE	0.1440	MAE	0.2536	Time	262.298346
Sample size	32	iteration number	201	MSE	0.1314	MAE	0.2488	Time	262.298584
Sample size	32	iteration number	211	MSE	0.1653	MAE	0.2889	Time	279.253244
Sample size	32	iteration number	221	MSE	0.3054	MAE	0.3616	Time	285.239935
Sample size	32	iteration number	231	MSE	0.1361	MAE	0.2372	Time	260.272741
Sample size	32	iteration number	241	MSE	0.1360	MAE	0.2613	Time	278.257847
Sample size	32	iteration number	251	MSE	0.1783	MAE	0.2810	Time	259.306908
Sample size	32	iteration number	261	MSE	0.1721	MAE	0.2944	Time	261.200190
Sample size	32	iteration number	271	MSE	0.1261	MAE	0.2422	Time	262.598038
Sample size	32	iteration number	281	MSE	0.2743	MAE	0.3352	Time	263.620138
Sample size	32	iteration number	291	MSE	0.1770	MAE	0.2818	Time	260.463238
Sample size	32	iteration number	301	MSE	0.1677	MAE	0.2768	Time	255.281448
Sample size	32	iteration number	311	MSE	0.2146	MAE	0.3041	Time	262.299538
Sample size	32	iteration number	321	MSE	0.1409	MAE	0.2407	Time	262.299299
Sample size	32	iteration number	331	MSE	0.1962	MAE	0.2948	Time	260.303974
Sample size	32	iteration number	341	MSE	0.1491	MAE	0.2411	Time	293.215990
Sample size	32	iteration number	351	MSE	0.2122	MAE	0.2780	Time	260.316610
Sample size	32	iteration number	361	MSE	0.1520	MAE	0.2528	Time	261.301517
Sample size	32	iteration number	371	MSE	0.1190	MAE	0.2483	Time	276.259899
Sample size	32	iteration number	381	MSE	0.1251	MAE	0.2281	Time	242.231846
Sample size	32	iteration number	391	MSE	0.0921	MAE	0.2039	Time	257.280827
Sample size	32	iteration number	401	MSE	0.1055	MAE	0.2048	Time	265.259027
Sample size	32	iteration number	411	MSE	0.1597	MAE	0.2625	Time	262.291908
Sample size	32	iteration number	421	MSE	0.1650	MAE	0.2536	Time	261.301517
Sample size	32	iteration number	431	MSE	0.1353	MAE	0.2449	Time	259.276628
Sample size	32	iteration number	441	MSE	0.0783	MAE	0.1947	Time	271.273851
Sample size	32	iteration number	451	MSE	0.2321	MAE	0.3119	Time	264.292955
Sample size	32	iteration number	461	MSE	0.1531	MAE	0.2576	Time	266.286373
Sample size	32	iteration number	471	MSE	0.1214	MAE	0.2334	Time	263.346910
Sample size	32	iteration number	481	MSE	0.1249	MAE	0.2353	Time	264.324665
Sample size	32	iteration number	491	MSE	0.1664	MAE	0.2696	Time	265.290499
Sample size	32	iteration number	501	MSE	0.1920	MAE	0.2879	Time	320.183516
Sample size	32	iteration number	511	MSE	0.2233	MAE	0.2954	Time	263.326883
Sample size	32	iteration number	521	MSE	0.1768	MAE	0.2464	Time	269.247293
Sample size	32	iteration number	531	MSE	0.1060	MAE	0.2353	Time	262.300014
Sample size	32	iteration number	541	MSE	0.0617	MAE	0.1624	Time	261.300325
Sample size	32	iteration number	551	MSE	0.1186	MAE	0.2297	Time	264.293432
Sample size	32	iteration number	561	MSE	0.1591	MAE	0.2715	Time	261.301279
Sample size	32	iteration number	571	MSE	0.0852	MAE	0.1897	Time	265.291214
Sample size	32	iteration number	581	MSE	0.2228	MAE	0.2691	Time	261.301041
Sample size	32	iteration number	591	MSE	0.2145	MAE	0.2859	Time	265.256166
Sample size	32	iteration number	601	MSE	0.1298	MAE	0.2180	Time	258.342981

Sample size	32	iteration number	611	MSE	0.0938	MAE	0.2141	Time	266.254187
Sample size	32	iteration number	621	MSE	0.1170	MAE	0.2097	Time	321.173668
Sample size	32	iteration number	631	MSE	0.1112	MAE	0.2193	Time	324.135780
Sample size	32	iteration number	641	MSE	0.1003	MAE	0.2176	Time	323.169231
Sample size	32	iteration number	651	MSE	0.1451	MAE	0.2590	Time	261.378288
Sample size	32	iteration number	661	MSE	0.0699	MAE	0.1791	Time	262.364626
Sample size	32	iteration number	671	MSE	0.1062	MAE	0.2187	Time	265.290499
Sample size	32	iteration number	681	MSE	0.1678	MAE	0.2855	Time	255.316973
Sample size	32	iteration number	691	MSE	0.1319	MAE	0.2394	Time	262.298822
Sample size	32	iteration number	701	MSE	0.1788	MAE	0.2723	Time	265.290737
Sample size	32	iteration number	711	MSE	0.1501	MAE	0.2438	Time	263.294697
Sample size	32	iteration number	721	MSE	0.1272	MAE	0.2296	Time	261.287928
Sample size	32	iteration number	731	MSE	0.1204	MAE	0.2257	Time	259.272337
Sample size	32	iteration number	741	MSE	0.0811	MAE	0.1960	Time	261.414766
Sample size	32	iteration number	751	MSE	0.0891	MAE	0.1916	Time	264.292955
Sample size	32	iteration number	761	MSE	0.1992	MAE	0.2636	Time	260.273457
Sample size	32	iteration number	771	MSE	0.1291	MAE	0.2265	Time	257.312059
Sample size	32	iteration number	781	MSE	0.1527	MAE	0.2349	Time	267.285824
Sample size	32	iteration number	791	MSE	0.1295	MAE	0.2443	Time	264.293432
Sample size	32	iteration number	801	MSE	0.2025	MAE	0.2840	Time	267.499208
Sample size	32	iteration number	811	MSE	0.1252	MAE	0.2486	Time	262.897015
Sample size	32	iteration number	821	MSE	0.1542	MAE	0.2533	Time	268.282175
Sample size	32	iteration number	831	MSE	0.1170	MAE	0.2406	Time	266.288280
Sample size	32	iteration number	841	MSE	0.1056	MAE	0.2015	Time	264.325619
Sample size	32	iteration number	851	MSE	0.1302	MAE	0.2185	Time	263.295889
Sample size	32	iteration number	861	MSE	0.1502	MAE	0.2664	Time	251.512051
Sample size	32	iteration number	871	MSE	0.1981	MAE	0.3108	Time	271.306753
Sample size	32	iteration number	881	MSE	0.1613	MAE	0.2483	Time	321.139574
Sample size	32	iteration number	891	MSE	0.0867	MAE	0.2018	Time	262.297630
Sample size	32	iteration number	901	MSE	0.1113	MAE	0.2078	Time	260.766506
Sample size	32	iteration number	911	MSE	0.0930	MAE	0.1967	Time	319.144487
Sample size	32	iteration number	921	MSE	0.1155	MAE	0.2205	Time	258.310318
Sample size	32	iteration number	931	MSE	0.1593	MAE	0.2506	Time	260.272264
Sample size	32	iteration number	941	MSE	0.1346	MAE	0.2544	Time	264.325380
Sample size	32	iteration number	951	MSE	0.1326	MAE	0.2388	Time	252.869844
Sample size	32	iteration number	961	MSE	0.1218	MAE	0.2297	Time	262.267113
Sample size	32	iteration number	971	MSE	0.1091	MAE	0.2012	Time	267.316818
Sample size	32	iteration number	981	MSE	0.1796	MAE	0.2511	Time	264.292002
Sample size	32	iteration number	991	MSE	0.1049	MAE	0.2148	Time	260.339499
Sample size	32	iteration number	1001	MSE	0.1208	MAE	0.2101	Time	266.288042
Sample size	128	iteration number	1	MSE	0.1109	MAE	0.2175	Time	460.767746
Sample size	128	iteration number	11	MSE	0.1176	MAE	0.2205	Time	439.790726
Sample size	128	iteration number	21	MSE	0.1360	MAE	0.2330	Time	443.805933
Sample size	128	iteration number	31	MSE	0.1076	MAE	0.1976	Time	436.833143
Sample size	128	iteration number	41	MSE	0.0996	MAE	0.1980	Time	439.825058
Sample size	128	iteration number	51	MSE	0.0998	MAE	0.1979	Time	505.603313
Sample size	128	iteration number	61	MSE	0.1378	MAE	0.2306	Time	440.761805
Sample size	128	iteration number	71	MSE	0.1034	MAE	0.1864	Time	440.820932

Sample size	128	iteration number	81	MSE	0.1075	MAE	0.2069	Time	434.836388
Sample size	128	iteration number	91	MSE	0.1106	MAE	0.2082	Time	442.816019
Sample size	128	iteration number	101	MSE	0.1049	MAE	0.2018	Time	438.860893
Sample size	128	iteration number	111	MSE	0.0901	MAE	0.1938	Time	434.877157
Sample size	128	iteration number	121	MSE	0.0954	MAE	0.1831	Time	437.829494
Sample size	128	iteration number	131	MSE	0.1083	MAE	0.1960	Time	439.791918
Sample size	128	iteration number	141	MSE	0.0920	MAE	0.1792	Time	441.818953
Sample size	128	iteration number	151	MSE	0.0840	MAE	0.1783	Time	444.842815
Sample size	128	iteration number	161	MSE	0.0964	MAE	0.1994	Time	437.861681
Sample size	128	iteration number	171	MSE	0.1026	MAE	0.2016	Time	435.835123
Sample size	128	iteration number	181	MSE	0.0873	MAE	0.1847	Time	431.845427
Sample size	128	iteration number	191	MSE	0.0937	MAE	0.1931	Time	437.829494
Sample size	128	iteration number	201	MSE	0.0901	MAE	0.1938	Time	440.855980
Sample size	128	iteration number	211	MSE	0.0798	MAE	0.1829	Time	438.859940
Sample size	128	iteration number	221	MSE	0.1017	MAE	0.1922	Time	442.847490
Sample size	128	iteration number	231	MSE	0.0819	MAE	0.1754	Time	435.834885
Sample size	128	iteration number	241	MSE	0.1097	MAE	0.1998	Time	435.866117
Sample size	128	iteration number	251	MSE	0.0917	MAE	0.1997	Time	437.860727
Sample size	128	iteration number	261	MSE	0.1121	MAE	0.2125	Time	435.834885
Sample size	128	iteration number	271	MSE	0.1245	MAE	0.2162	Time	443.782091
Sample size	128	iteration number	281	MSE	0.0842	MAE	0.1874	Time	437.829971
Sample size	128	iteration number	291	MSE	0.0906	MAE	0.1995	Time	435.869455
Sample size	128	iteration number	301	MSE	0.0818	MAE	0.1813	Time	433.840036
Sample size	128	iteration number	311	MSE	0.0904	MAE	0.1866	Time	434.837341
Sample size	128	iteration number	321	MSE	0.0894	MAE	0.1906	Time	433.840036
Sample size	128	iteration number	331	MSE	0.1110	MAE	0.2172	Time	433.840036
Sample size	128	iteration number	341	MSE	0.1147	MAE	0.2195	Time	435.833454
Sample size	128	iteration number	351	MSE	0.0812	MAE	0.1735	Time	434.864521
Sample size	128	iteration number	361	MSE	0.0903	MAE	0.1806	Time	437.829018
Sample size	128	iteration number	371	MSE	0.0902	MAE	0.1811	Time	436.799288
Sample size	128	iteration number	381	MSE	0.0756	MAE	0.1712	Time	432.842970
Sample size	128	iteration number	391	MSE	0.0757	MAE	0.1724	Time	440.821648
Sample size	128	iteration number	401	MSE	0.0908	MAE	0.1782	Time	432.810307
Sample size	128	iteration number	411	MSE	0.0663	MAE	0.1637	Time	442.848206
Sample size	128	iteration number	421	MSE	0.0733	MAE	0.1769	Time	441.850662
Sample size	128	iteration number	431	MSE	0.0797	MAE	0.1822	Time	433.839560
Sample size	128	iteration number	441	MSE	0.0885	MAE	0.1802	Time	443.815231
Sample size	128	iteration number	451	MSE	0.0820	MAE	0.1830	Time	437.795162
Sample size	128	iteration number	461	MSE	0.0982	MAE	0.1972	Time	434.786081
Sample size	128	iteration number	471	MSE	0.0999	MAE	0.2009	Time	436.866999
Sample size	128	iteration number	481	MSE	0.0996	MAE	0.1828	Time	439.874172
Sample size	128	iteration number	491	MSE	0.0710	MAE	0.1721	Time	500.660181
Sample size	128	iteration number	501	MSE	0.0952	MAE	0.1913	Time	439.855576
Sample size	128	iteration number	511	MSE	0.0764	MAE	0.1733	Time	508.638382
Sample size	128	iteration number	521	MSE	0.1072	MAE	0.1915	Time	500.695467
Sample size	128	iteration number	531	MSE	0.1070	MAE	0.2035	Time	439.790010
Sample size	128	iteration number	541	MSE	0.0881	MAE	0.1849	Time	502.634048
Sample size	128	iteration number	551	MSE	0.0829	MAE	0.1756	Time	506.613255

Sample size	128	iteration number	561	MSE	0.0925	MAE	0.1816	Time	435.806990
Sample size	128	iteration number	571	MSE	0.0903	MAE	0.1828	Time	430.879116
Sample size	128	iteration number	581	MSE	0.0953	MAE	0.1794	Time	433.840036
Sample size	128	iteration number	591	MSE	0.0898	MAE	0.1864	Time	439.823866
Sample size	128	iteration number	601	MSE	0.0941	MAE	0.1832	Time	434.805632
Sample size	128	iteration number	611	MSE	0.0799	MAE	0.1778	Time	423.253059
Sample size	128	iteration number	621	MSE	0.0866	MAE	0.1822	Time	436.831713
Sample size	128	iteration number	631	MSE	0.0801	MAE	0.1705	Time	436.831713
Sample size	128	iteration number	641	MSE	0.1272	MAE	0.2027	Time	436.831951
Sample size	128	iteration number	651	MSE	0.1007	MAE	0.1941	Time	431.845188
Sample size	128	iteration number	661	MSE	0.0960	MAE	0.1930	Time	436.832190
Sample size	128	iteration number	671	MSE	0.0976	MAE	0.1875	Time	439.824581
Sample size	128	iteration number	681	MSE	0.0990	MAE	0.1994	Time	435.803175
Sample size	128	iteration number	691	MSE	0.0953	MAE	0.1869	Time	438.795328
Sample size	128	iteration number	701	MSE	0.0828	MAE	0.1727	Time	439.216375
Sample size	128	iteration number	711	MSE	0.0922	MAE	0.1900	Time	437.828302
Sample size	128	iteration number	721	MSE	0.0911	MAE	0.1784	Time	441.786051
Sample size	128	iteration number	731	MSE	0.0806	MAE	0.1785	Time	430.848122
Sample size	128	iteration number	741	MSE	0.0846	MAE	0.1835	Time	438.826799
Sample size	128	iteration number	751	MSE	0.1126	MAE	0.2108	Time	437.797546
Sample size	128	iteration number	761	MSE	0.0715	MAE	0.1627	Time	434.836626
Sample size	128	iteration number	771	MSE	0.0913	MAE	0.1921	Time	436.863661
Sample size	128	iteration number	781	MSE	0.0712	MAE	0.1607	Time	444.807529
Sample size	128	iteration number	791	MSE	0.0691	MAE	0.1693	Time	505.616903
Sample size	128	iteration number	801	MSE	0.0928	MAE	0.1941	Time	434.783220
Sample size	128	iteration number	811	MSE	0.1112	MAE	0.2052	Time	431.844234
Sample size	128	iteration number	821	MSE	0.0838	MAE	0.1824	Time	439.826250
Sample size	128	iteration number	831	MSE	0.0975	MAE	0.1866	Time	436.864376
Sample size	128	iteration number	841	MSE	0.0847	MAE	0.1772	Time	435.835838
Sample size	128	iteration number	851	MSE	0.0833	MAE	0.1849	Time	444.810867
Sample size	128	iteration number	861	MSE	0.1185	MAE	0.2183	Time	502.629519
Sample size	128	iteration number	871	MSE	0.1162	MAE	0.2079	Time	441.851377
Sample size	128	iteration number	881	MSE	0.0968	MAE	0.2002	Time	434.806108
Sample size	128	iteration number	891	MSE	0.0862	MAE	0.1694	Time	443.813324
Sample size	128	iteration number	901	MSE	0.0854	MAE	0.1783	Time	440.771103
Sample size	128	iteration number	911	MSE	0.1220	MAE	0.2139	Time	439.823627
Sample size	128	iteration number	921	MSE	0.0697	MAE	0.1648	Time	432.811022
Sample size	128	iteration number	931	MSE	0.0971	MAE	0.1943	Time	438.826323
Sample size	128	iteration number	941	MSE	0.0993	MAE	0.1982	Time	440.789223
Sample size	128	iteration number	951	MSE	0.0973	MAE	0.1975	Time	431.813717
Sample size	128	iteration number	961	MSE	0.0875	MAE	0.1835	Time	435.834408
Sample size	128	iteration number	971	MSE	0.0759	MAE	0.1718	Time	431.449175
Sample size	128	iteration number	981	MSE	0.0917	MAE	0.1816	Time	446.805954
Sample size	128	iteration number	991	MSE	0.1007	MAE	0.2027	Time	443.851709
Sample size	128	iteration number	1001	MSE	0.1012	MAE	0.1980	Time	441.785574
Sample size	512	iteration number	1	MSE	0.0896	MAE	0.1914	Time	1158.33663
Sample size	512	iteration number	11	MSE	0.0833	MAE	0.1742	Time	1149.92523
Sample size	512	iteration number	21	MSE	0.0849	MAE	0.1797	Time	1157.88650

Sample size	512	iteration number	31	MSE	0.0926	MAE	0.1881	Time	1219.75755
Sample size	512	iteration number	41	MSE	0.0787	MAE	0.1702	Time	1145.93601
Sample size	512	iteration number	51	MSE	0.0899	MAE	0.1733	Time	1141.95251
Sample size	512	iteration number	61	MSE	0.0880	MAE	0.1792	Time	1165.87543
Sample size	512	iteration number	71	MSE	0.0854	MAE	0.1714	Time	1150.89100
Sample size	512	iteration number	81	MSE	0.0866	MAE	0.1751	Time	1157.93919
Sample size	512	iteration number	91	MSE	0.0892	MAE	0.1830	Time	1152.72593
Sample size	512	iteration number	101	MSE	0.0744	MAE	0.1669	Time	1131.78205
Sample size	512	iteration number	111	MSE	0.0704	MAE	0.1613	Time	1149.49846
Sample size	512	iteration number	121	MSE	0.0852	MAE	0.1745	Time	1152.91953
Sample size	512	iteration number	131	MSE	0.0898	MAE	0.1804	Time	1152.90713
Sample size	512	iteration number	141	MSE	0.0841	MAE	0.1722	Time	1160.98642
Sample size	512	iteration number	151	MSE	0.0753	MAE	0.1640	Time	1153.92136
Sample size	512	iteration number	161	MSE	0.0853	MAE	0.1772	Time	1135.92720
Sample size	512	iteration number	171	MSE	0.0874	MAE	0.1753	Time	1141.98398
Sample size	512	iteration number	181	MSE	0.0749	MAE	0.1664	Time	1138.95440
Sample size	512	iteration number	191	MSE	0.0788	MAE	0.1707	Time	1142.94052
Sample size	512	iteration number	201	MSE	0.0941	MAE	0.1824	Time	1141.95275
Sample size	512	iteration number	211	MSE	0.0763	MAE	0.1685	Time	1155.96532
Sample size	512	iteration number	221	MSE	0.0734	MAE	0.1682	Time	1133.99910
Sample size	512	iteration number	231	MSE	0.0728	MAE	0.1661	Time	1138.96060
Sample size	512	iteration number	241	MSE	0.0741	MAE	0.1722	Time	1141.91222
Sample size	512	iteration number	251	MSE	0.0860	MAE	0.1791	Time	1146.93379
Sample size	512	iteration number	261	MSE	0.0710	MAE	0.1597	Time	1146.93093
Sample size	512	iteration number	271	MSE	0.0809	MAE	0.1687	Time	1153.91492
Sample size	512	iteration number	281	MSE	0.0801	MAE	0.1706	Time	1142.91167
Sample size	512	iteration number	291	MSE	0.0770	MAE	0.1710	Time	1148.97847
Sample size	512	iteration number	301	MSE	0.0755	MAE	0.1690	Time	1158.93292
Sample size	512	iteration number	311	MSE	0.0868	MAE	0.1815	Time	1165.88187
Sample size	512	iteration number	321	MSE	0.0831	MAE	0.1731	Time	1153.91588
Sample size	512	iteration number	331	MSE	0.0762	MAE	0.1673	Time	1147.93252
Sample size	512	iteration number	341	MSE	0.0738	MAE	0.1668	Time	1142.91167
Sample size	512	iteration number	351	MSE	0.0775	MAE	0.1663	Time	1139.95289
Sample size	512	iteration number	361	MSE	0.0660	MAE	0.1579	Time	1147.92609
Sample size	512	iteration number	371	MSE	0.0752	MAE	0.1685	Time	1168.73478
Sample size	512	iteration number	381	MSE	0.0908	MAE	0.1795	Time	1134.99665
Sample size	512	iteration number	391	MSE	0.0670	MAE	0.1583	Time	1131.97660
Sample size	512	iteration number	401	MSE	0.0693	MAE	0.1587	Time	1222.73063
Sample size	512	iteration number	411	MSE	0.0835	MAE	0.1695	Time	1140.89822
Sample size	512	iteration number	421	MSE	0.0732	MAE	0.1657	Time	1148.92816
Sample size	512	iteration number	431	MSE	0.0788	MAE	0.1690	Time	1136.96575
Sample size	512	iteration number	441	MSE	0.0814	MAE	0.1758	Time	1140.91706
Sample size	512	iteration number	451	MSE	0.0786	MAE	0.1739	Time	1140.94376
Sample size	512	iteration number	461	MSE	0.0765	MAE	0.1684	Time	1153.92828
Sample size	512	iteration number	471	MSE	0.0798	MAE	0.1744	Time	1149.92618
Sample size	512	iteration number	481	MSE	0.0748	MAE	0.1701	Time	1158.87665
Sample size	512	iteration number	491	MSE	0.0675	MAE	0.1518	Time	1166.87989
Sample size	512	iteration number	501	MSE	0.0781	MAE	0.1650	Time	1141.94726

Sample size	512	iteration number	511	MSE	0.0721	MAE	0.1633	Time	1150.43830
Sample size	512	iteration number	521	MSE	0.0754	MAE	0.1661	Time	1148.95939
Sample size	512	iteration number	531	MSE	0.0741	MAE	0.1645	Time	1157.92918
Sample size	512	iteration number	541	MSE	0.0768	MAE	0.1694	Time	1144.95444
Sample size	512	iteration number	551	MSE	0.0768	MAE	0.1704	Time	1147.94969
Sample size	512	iteration number	561	MSE	0.0748	MAE	0.1689	Time	1154.91175
Sample size	512	iteration number	571	MSE	0.0655	MAE	0.1535	Time	1156.88467
Sample size	512	iteration number	581	MSE	0.0780	MAE	0.1733	Time	1159.89756
Sample size	512	iteration number	591	MSE	0.0875	MAE	0.1802	Time	1149.92523
Sample size	512	iteration number	601	MSE	0.0747	MAE	0.1650	Time	1154.93178
Sample size	512	iteration number	611	MSE	0.0687	MAE	0.1627	Time	1155.94077
Sample size	512	iteration number	621	MSE	0.0685	MAE	0.1621	Time	1140.95068
Sample size	512	iteration number	631	MSE	0.0814	MAE	0.1698	Time	1168.18499
Sample size	512	iteration number	641	MSE	0.0821	MAE	0.1756	Time	1159.93118
Sample size	512	iteration number	651	MSE	0.0730	MAE	0.1615	Time	1157.90271
Sample size	512	iteration number	661	MSE	0.0841	MAE	0.1779	Time	1146.90208
Sample size	512	iteration number	671	MSE	0.0703	MAE	0.1611	Time	1147.92799
Sample size	512	iteration number	681	MSE	0.0782	MAE	0.1697	Time	1140.98382
Sample size	512	iteration number	691	MSE	0.0783	MAE	0.1654	Time	1140.95783
Sample size	512	iteration number	701	MSE	0.0753	MAE	0.1662	Time	1146.93093
Sample size	512	iteration number	711	MSE	0.0860	MAE	0.1772	Time	1145.90311
Sample size	512	iteration number	721	MSE	0.0728	MAE	0.1619	Time	1141.92962
Sample size	512	iteration number	731	MSE	0.0733	MAE	0.1641	Time	1136.95740
Sample size	512	iteration number	741	MSE	0.0803	MAE	0.1717	Time	1134.96851
Sample size	512	iteration number	751	MSE	0.0821	MAE	0.1657	Time	1144.97327
Sample size	512	iteration number	761	MSE	0.0710	MAE	0.1601	Time	1153.96475
Sample size	512	iteration number	771	MSE	0.0796	MAE	0.1711	Time	1141.97111
Sample size	512	iteration number	781	MSE	0.0732	MAE	0.1653	Time	1140.94996
Sample size	512	iteration number	791	MSE	0.0727	MAE	0.1597	Time	1166.91327
Sample size	512	iteration number	801	MSE	0.0780	MAE	0.1718	Time	1142.93599
Sample size	512	iteration number	811	MSE	0.0786	MAE	0.1691	Time	1140.92230
Sample size	512	iteration number	821	MSE	0.0767	MAE	0.1677	Time	1142.94409
Sample size	512	iteration number	831	MSE	0.0683	MAE	0.1588	Time	1135.93030
Sample size	512	iteration number	841	MSE	0.0753	MAE	0.1695	Time	1139.92786
Sample size	512	iteration number	851	MSE	0.0771	MAE	0.1668	Time	1158.90479
Sample size	512	iteration number	861	MSE	0.0718	MAE	0.1654	Time	1161.89312
Sample size	512	iteration number	871	MSE	0.0776	MAE	0.1651	Time	1153.91492
Sample size	512	iteration number	881	MSE	0.0818	MAE	0.1747	Time	1158.93197
Sample size	512	iteration number	891	MSE	0.0763	MAE	0.1695	Time	1151.95465
Sample size	512	iteration number	901	MSE	0.0741	MAE	0.1712	Time	1159.84082
Sample size	512	iteration number	911	MSE	0.0733	MAE	0.1647	Time	1136.95979
Sample size	512	iteration number	921	MSE	0.0758	MAE	0.1653	Time	1136.96003
Sample size	512	iteration number	931	MSE	0.0688	MAE	0.1563	Time	1151.92532
Sample size	512	iteration number	941	MSE	0.0749	MAE	0.1700	Time	1132.97176
Sample size	512	iteration number	951	MSE	0.0659	MAE	0.1574	Time	1142.94314
Sample size	512	iteration number	961	MSE	0.0814	MAE	0.1758	Time	1143.96596
Sample size	512	iteration number	971	MSE	0.0833	MAE	0.1746	Time	1138.92126
Sample size	512	iteration number	981	MSE	0.0670	MAE	0.1556	Time	1140.91444

Sample size	512	iteration number	991	MSE	0.0714	MAE	0.1626	Time	1144.97184
Sample size	512	iteration number	1001	MSE	0.0778	MAE	0.1691	Time	1154.91557
Sample size	512	iteration number	1011	MSE	0.0809	MAE	0.1742	Time	1142.94099
Sample size	512	iteration number	1021	MSE	0.0738	MAE	0.1659	Time	1140.95616
Sample size	512	iteration number	1031	MSE	0.0757	MAE	0.1667	Time	1165.92073
Sample size	512	iteration number	1041	MSE	0.0760	MAE	0.1696	Time	1151.91507
Sample size	512	iteration number	1051	MSE	0.0786	MAE	0.1697	Time	1146.93307
Sample size	512	iteration number	1061	MSE	0.0763	MAE	0.1644	Time	1152.91762
Sample size	512	iteration number	1071	MSE	0.0710	MAE	0.1578	Time	1138.92245
Sample size	512	iteration number	1081	MSE	0.0726	MAE	0.1645	Time	1139.94884
Sample size	512	iteration number	1091	MSE	0.0795	MAE	0.1718	Time	1141.96562
Sample size	512	iteration number	1101	MSE	0.0780	MAE	0.1745	Time	1144.93775
Sample size	512	iteration number	1111	MSE	0.0796	MAE	0.1665	Time	1141.92366
Sample size	512	iteration number	1121	MSE	0.0852	MAE	0.1793	Time	1144.93560
Sample size	512	iteration number	1131	MSE	0.0745	MAE	0.1614	Time	1135.96510
Sample size	512	iteration number	1141	MSE	0.0672	MAE	0.1571	Time	1134.91487
Sample size	512	iteration number	1151	MSE	0.0761	MAE	0.1691	Time	1143.90993
Sample size	512	iteration number	1161	MSE	0.0712	MAE	0.1656	Time	1155.94458
Sample size	512	iteration number	1171	MSE	0.0751	MAE	0.1643	Time	1137.96091
Sample size	512	iteration number	1181	MSE	0.0675	MAE	0.1563	Time	1141.94393
Sample size	512	iteration number	1191	MSE	0.0790	MAE	0.1685	Time	1143.90993
Sample size	512	iteration number	1201	MSE	0.0725	MAE	0.1681	Time	1153.91492
Sample size	512	iteration number	1211	MSE	0.0814	MAE	0.1728	Time	1156.90660
Sample size	512	iteration number	1221	MSE	0.0795	MAE	0.1687	Time	1157.87220
Sample size	512	iteration number	1231	MSE	0.0771	MAE	0.1700	Time	1155.91263
Sample size	512	iteration number	1241	MSE	0.0698	MAE	0.1559	Time	1182.14249
Sample size	512	iteration number	1251	MSE	0.0891	MAE	0.1791	Time	1223.75631
Sample size	512	iteration number	1261	MSE	0.0775	MAE	0.1689	Time	1140.00272
Sample size	512	iteration number	1271	MSE	0.0813	MAE	0.1699	Time	1141.94583
Sample size	512	iteration number	1281	MSE	0.0798	MAE	0.1720	Time	1143.90754
Sample size	512	iteration number	1291	MSE	0.0723	MAE	0.1659	Time	1137.96067
Sample size	512	iteration number	1301	MSE	0.0857	MAE	0.1819	Time	1149.95050
Sample size	512	iteration number	1311	MSE	0.0719	MAE	0.1676	Time	1159.89661
Sample size	512	iteration number	1321	MSE	0.0766	MAE	0.1674	Time	1159.89899
Sample size	512	iteration number	1331	MSE	0.0835	MAE	0.1736	Time	1150.92206
Sample size	512	iteration number	1341	MSE	0.0788	MAE	0.1729	Time	1157.93728
Sample size	512	iteration number	1351	MSE	0.0774	MAE	0.1694	Time	1142.94409
Sample size	512	iteration number	1361	MSE	0.0814	MAE	0.1723	Time	1139.95146
Sample size	512	iteration number	1371	MSE	0.0703	MAE	0.1630	Time	1140.91372
Sample size	512	iteration number	1381	MSE	0.0662	MAE	0.1579	Time	1144.93966
Sample size	512	iteration number	1391	MSE	0.0782	MAE	0.1690	Time	1146.92258
Sample size	512	iteration number	1401	MSE	0.0650	MAE	0.1545	Time	1157.90510
Sample size	512	iteration number	1411	MSE	0.0719	MAE	0.1616	Time	1159.89899
Sample size	512	iteration number	1421	MSE	0.0809	MAE	0.1718	Time	1214.80703
Sample size	512	iteration number	1431	MSE	0.0687	MAE	0.1636	Time	1135.96200
Sample size	512	iteration number	1441	MSE	0.0793	MAE	0.1730	Time	1148.94700
Sample size	512	iteration number	1451	MSE	0.0753	MAE	0.1631	Time	1158.90145
Sample size	512	iteration number	1461	MSE	0.0760	MAE	0.1678	Time	1137.96448

Sample size	512	iteration number	1471	MSE	0.0759	MAE	0.1631	Time	1147.96328
Sample size	512	iteration number	1481	MSE	0.0700	MAE	0.1616	Time	1144.93751
Sample size	512	iteration number	1491	MSE	0.0839	MAE	0.1811	Time	1143.93544
Sample size	512	iteration number	1501	MSE	0.0815	MAE	0.1682	Time	1138.96274
Sample size	512	iteration number	1511	MSE	0.0850	MAE	0.1735	Time	1138.92102
Sample size	512	iteration number	1521	MSE	0.0703	MAE	0.1639	Time	1174.80516
Sample size	512	iteration number	1531	MSE	0.0771	MAE	0.1630	Time	1155.90858
Sample size	512	iteration number	1541	MSE	0.0659	MAE	0.1532	Time	1140.98143
Sample size	512	iteration number	1551	MSE	0.0847	MAE	0.1745	Time	1144.93846
Sample size	512	iteration number	1561	MSE	0.0753	MAE	0.1686	Time	1141.94893
Sample size	512	iteration number	1571	MSE	0.0809	MAE	0.1711	Time	1143.90707
Sample size	512	iteration number	1581	MSE	0.0816	MAE	0.1706	Time	1145.93648
Sample size	512	iteration number	1591	MSE	0.0675	MAE	0.1585	Time	1143.93281
Sample size	512	iteration number	1601	MSE	0.0774	MAE	0.1697	Time	1150.95710
Sample size	512	iteration number	1611	MSE	0.0708	MAE	0.1626	Time	1151.94964
Sample size	512	iteration number	1621	MSE	0.0723	MAE	0.1591	Time	1154.94418
Sample size	512	iteration number	1631	MSE	0.0797	MAE	0.1701	Time	1151.88598
Sample size	512	iteration number	1641	MSE	0.0736	MAE	0.1642	Time	1157.90605
Sample size	512	iteration number	1651	MSE	0.0808	MAE	0.1702	Time	1147.96233
Sample size	512	iteration number	1661	MSE	0.0671	MAE	0.1603	Time	1137.95733
Sample size	512	iteration number	1671	MSE	0.0765	MAE	0.1683	Time	1154.91199
Sample size	512	iteration number	1681	MSE	0.0690	MAE	0.1585	Time	1154.94632
Sample size	512	iteration number	1691	MSE	0.0739	MAE	0.1634	Time	1150.92372
Sample size	512	iteration number	1701	MSE	0.0789	MAE	0.1711	Time	1153.91111
Sample size	512	iteration number	1711	MSE	0.0693	MAE	0.1595	Time	1158.90169
Sample size	512	iteration number	1721	MSE	0.0703	MAE	0.1588	Time	1158.90741
Sample size	512	iteration number	1731	MSE	0.0709	MAE	0.1559	Time	1144.79160
Sample size	512	iteration number	1741	MSE	0.0741	MAE	0.1625	Time	1143.94164
Sample size	512	iteration number	1751	MSE	0.0708	MAE	0.1638	Time	1155.90834
Sample size	512	iteration number	1761	MSE	0.0744	MAE	0.1663	Time	1153.29217
Sample size	512	iteration number	1771	MSE	0.0804	MAE	0.1704	Time	1138.95726
Sample size	512	iteration number	1781	MSE	0.0798	MAE	0.1660	Time	1143.94140
Sample size	512	iteration number	1791	MSE	0.0757	MAE	0.1644	Time	1144.93560
Sample size	512	iteration number	1801	MSE	0.0805	MAE	0.1694	Time	1138.97299
Sample size	512	iteration number	1811	MSE	0.0755	MAE	0.1679	Time	1136.92760
Sample size	512	iteration number	1821	MSE	0.0744	MAE	0.1646	Time	1143.94927
Sample size	512	iteration number	1831	MSE	0.0735	MAE	0.1695	Time	1137.93396
Sample size	512	iteration number	1841	MSE	0.0799	MAE	0.1701	Time	1132.97104
Sample size	512	iteration number	1851	MSE	0.0744	MAE	0.1648	Time	1135.93077
Sample size	512	iteration number	1861	MSE	0.0732	MAE	0.1666	Time	1144.90318
Sample size	512	iteration number	1871	MSE	0.0746	MAE	0.1610	Time	1143.97478
Sample size	512	iteration number	1881	MSE	0.0683	MAE	0.1620	Time	1162.88948
Sample size	512	iteration number	1891	MSE	0.0724	MAE	0.1696	Time	1142.91262
Sample size	512	iteration number	1901	MSE	0.0711	MAE	0.1668	Time	1137.92634
Sample size	512	iteration number	1911	MSE	0.0701	MAE	0.1618	Time	1154.96921
Sample size	512	iteration number	1921	MSE	0.0781	MAE	0.1692	Time	1155.90858
Sample size	512	iteration number	1931	MSE	0.0798	MAE	0.1634	Time	1144.95158
Sample size	512	iteration number	1941	MSE	0.0776	MAE	0.1665	Time	1144.95611

Sample size	512	iteration number	1951	MSE	0.0775	MAE	0.1677	Time	1142.97604
Sample size	512	iteration number	1961	MSE	0.0640	MAE	0.1543	Time	1156.88228
Sample size	512	iteration number	1971	MSE	0.0728	MAE	0.1639	Time	1149.42002
Sample size	512	iteration number	1981	MSE	0.0735	MAE	0.1654	Time	1137.92610
Sample size	512	iteration number	1991	MSE	0.0719	MAE	0.1623	Time	1145.93315
Sample size	512	iteration number	2001	MSE	0.0839	MAE	0.1738	Time	1227.71501
Sample size	2048	iteration number	1	MSE	0.0785	MAE	0.1744	Time	3987.33973
Sample size	2048	iteration number	11	MSE	0.0664	MAE	0.1565	Time	3876.63435
Sample size	2048	iteration number	21	MSE	0.0720	MAE	0.1606	Time	3886.60717
Sample size	2048	iteration number	31	MSE	0.0684	MAE	0.1569	Time	3881.64758
Sample size	2048	iteration number	41	MSE	0.0728	MAE	0.1600	Time	3889.62674
Sample size	2048	iteration number	51	MSE	0.0703	MAE	0.1603	Time	3880.62429
Sample size	2048	iteration number	61	MSE	0.0733	MAE	0.1620	Time	3921.51284
Sample size	2048	iteration number	71	MSE	0.0697	MAE	0.1593	Time	3877.63166
Sample size	2048	iteration number	81	MSE	0.0706	MAE	0.1600	Time	3897.55010
Sample size	2048	iteration number	91	MSE	0.0744	MAE	0.1659	Time	3888.62896
Sample size	2048	iteration number	101	MSE	0.0726	MAE	0.1579	Time	3876.63459
Sample size	2048	iteration number	111	MSE	0.0756	MAE	0.1653	Time	3880.62977
Sample size	2048	iteration number	121	MSE	0.0702	MAE	0.1579	Time	3926.52654
Sample size	2048	iteration number	131	MSE	0.0763	MAE	0.1646	Time	3876.63435
Sample size	2048	iteration number	141	MSE	0.0723	MAE	0.1607	Time	3878.62825
Sample size	2048	iteration number	151	MSE	0.0697	MAE	0.1562	Time	3878.27992
Sample size	2048	iteration number	161	MSE	0.0712	MAE	0.1588	Time	3882.59196
Sample size	2048	iteration number	171	MSE	0.0697	MAE	0.1557	Time	3883.64243
Sample size	2048	iteration number	181	MSE	0.0669	MAE	0.1533	Time	3975.39830
Sample size	2048	iteration number	191	MSE	0.0690	MAE	0.1572	Time	3879.62698
Sample size	2048	iteration number	201	MSE	0.0685	MAE	0.1581	Time	3882.62271
Sample size	2048	iteration number	211	MSE	0.0665	MAE	0.1537	Time	3887.60495
Sample size	2048	iteration number	221	MSE	0.0668	MAE	0.1522	Time	3885.63752
Sample size	2048	iteration number	231	MSE	0.0752	MAE	0.1626	Time	3887.60519
Sample size	2048	iteration number	241	MSE	0.0774	MAE	0.1653	Time	3902.56500
Sample size	2048	iteration number	251	MSE	0.0703	MAE	0.1593	Time	3895.61080
Sample size	2048	iteration number	261	MSE	0.0652	MAE	0.1519	Time	3873.64816
Sample size	2048	iteration number	271	MSE	0.0763	MAE	0.1629	Time	3893.58758
Sample size	2048	iteration number	281	MSE	0.0759	MAE	0.1636	Time	3883.61620
Sample size	2048	iteration number	291	MSE	0.0678	MAE	0.1554	Time	3885.61010
Sample size	2048	iteration number	301	MSE	0.0730	MAE	0.1603	Time	3917.49787
Sample size	2048	iteration number	311	MSE	0.0751	MAE	0.1636	Time	3883.65197
Sample size	2048	iteration number	321	MSE	0.0738	MAE	0.1624	Time	3925.51016
Sample size	2048	iteration number	331	MSE	0.0704	MAE	0.1582	Time	3890.57183
Sample size	2048	iteration number	341	MSE	0.0717	MAE	0.1608	Time	3993.40891
Sample size	2048	iteration number	351	MSE	0.0746	MAE	0.1623	Time	3946.55060
Sample size	2048	iteration number	361	MSE	0.0719	MAE	0.1604	Time	3917.08445
Sample size	2048	iteration number	371	MSE	0.0683	MAE	0.1545	Time	3882.61294
Sample size	2048	iteration number	381	MSE	0.0694	MAE	0.1569	Time	3937.47210
Sample size	2048	iteration number	391	MSE	0.0675	MAE	0.1545	Time	3936.47456
Sample size	2048	iteration number	401	MSE	0.0700	MAE	0.1561	Time	3933.48288
Sample size	2048	iteration number	411	MSE	0.0725	MAE	0.1610	Time	3891.59178

Sample size	2048	iteration number	421	MSE	0.0763	MAE	0.1623	Time	3910.54463
Sample size	2048	iteration number	431	MSE	0.0706	MAE	0.1579	Time	3883.62169
Sample size	2048	iteration number	441	MSE	0.0682	MAE	0.1585	Time	3932.45339
Sample size	2048	iteration number	451	MSE	0.0732	MAE	0.1614	Time	3883.62145
Sample size	2048	iteration number	461	MSE	0.0791	MAE	0.1645	Time	3882.66205
Sample size	2048	iteration number	471	MSE	0.0711	MAE	0.1627	Time	3880.65028
Sample size	2048	iteration number	481	MSE	0.0731	MAE	0.1580	Time	3924.50666
Sample size	2048	iteration number	491	MSE	0.0698	MAE	0.1572	Time	3887.63427
Sample size	2048	iteration number	501	MSE	0.0675	MAE	0.1535	Time	3941.46156
Sample size	2048	iteration number	511	MSE	0.0706	MAE	0.1587	Time	3869.65274
Sample size	2048	iteration number	521	MSE	0.0711	MAE	0.1590	Time	3899.57237
Sample size	2048	iteration number	531	MSE	0.0718	MAE	0.1589	Time	3886.60645
Sample size	2048	iteration number	541	MSE	0.0709	MAE	0.1555	Time	3919.49319
Sample size	2048	iteration number	551	MSE	0.0686	MAE	0.1551	Time	3883.66985
Sample size	2048	iteration number	561	MSE	0.0668	MAE	0.1560	Time	3923.64096
Sample size	2048	iteration number	571	MSE	0.0732	MAE	0.1594	Time	3884.61327
Sample size	2048	iteration number	581	MSE	0.0778	MAE	0.1641	Time	3889.59980
Sample size	2048	iteration number	591	MSE	0.0755	MAE	0.1620	Time	3886.57736
Sample size	2048	iteration number	601	MSE	0.0631	MAE	0.1489	Time	3919.73328
Sample size	2048	iteration number	611	MSE	0.0685	MAE	0.1560	Time	3881.62994
Sample size	2048	iteration number	621	MSE	0.0654	MAE	0.1514	Time	3881.61945
Sample size	2048	iteration number	631	MSE	0.0693	MAE	0.1558	Time	3888.57007
Sample size	2048	iteration number	641	MSE	0.0700	MAE	0.1563	Time	3895.58291
Sample size	2048	iteration number	651	MSE	0.0739	MAE	0.1594	Time	3880.64432
Sample size	2048	iteration number	661	MSE	0.0721	MAE	0.1613	Time	3905.83300
Sample size	2048	iteration number	671	MSE	0.0712	MAE	0.1579	Time	3879.65369
Sample size	2048	iteration number	681	MSE	0.0673	MAE	0.1553	Time	3881.64806
Sample size	2048	iteration number	691	MSE	0.0683	MAE	0.1526	Time	3893.59188
Sample size	2048	iteration number	701	MSE	0.0716	MAE	0.1610	Time	3884.63926
Sample size	2048	iteration number	711	MSE	0.0762	MAE	0.1663	Time	3885.61034
Sample size	2048	iteration number	721	MSE	0.0716	MAE	0.1578	Time	3963.40203
Sample size	2048	iteration number	731	MSE	0.0732	MAE	0.1598	Time	3877.63118
Sample size	2048	iteration number	741	MSE	0.0709	MAE	0.1601	Time	3907.55224
Sample size	2048	iteration number	751	MSE	0.0653	MAE	0.1533	Time	3947.67046
Sample size	2048	iteration number	761	MSE	0.0687	MAE	0.1550	Time	3884.54484
Sample size	2048	iteration number	771	MSE	0.0709	MAE	0.1604	Time	3883.61549
Sample size	2048	iteration number	781	MSE	0.0704	MAE	0.1564	Time	3917.52553
Sample size	2048	iteration number	791	MSE	0.0718	MAE	0.1607	Time	3890.59734
Sample size	2048	iteration number	801	MSE	0.0732	MAE	0.1613	Time	3875.64253
Sample size	2048	iteration number	811	MSE	0.0709	MAE	0.1561	Time	3887.61472
Sample size	2048	iteration number	821	MSE	0.0691	MAE	0.1573	Time	3886.63530
Sample size	2048	iteration number	831	MSE	0.0699	MAE	0.1591	Time	3893.58592
Sample size	2048	iteration number	841	MSE	0.0677	MAE	0.1567	Time	3897.55106
Sample size	2048	iteration number	851	MSE	0.0676	MAE	0.1560	Time	3887.60566
Sample size	2048	iteration number	861	MSE	0.0680	MAE	0.1557	Time	3881.64353
Sample size	2048	iteration number	871	MSE	0.0685	MAE	0.1560	Time	3933.44998
Sample size	2048	iteration number	881	MSE	0.0716	MAE	0.1569	Time	3925.50516
Sample size	2048	iteration number	891	MSE	0.0693	MAE	0.1590	Time	3937.46686

Sample size	2048	iteration number	901	MSE	0.0664	MAE	0.1552	Time	3959.49101
Sample size	2048	iteration number	911	MSE	0.0718	MAE	0.1579	Time	3943.45617
Sample size	2048	iteration number	921	MSE	0.0679	MAE	0.1557	Time	3891.56675
Sample size	2048	iteration number	931	MSE	0.0698	MAE	0.1585	Time	3887.60423
Sample size	2048	iteration number	941	MSE	0.0691	MAE	0.1556	Time	3888.60225
Sample size	2048	iteration number	951	MSE	0.0621	MAE	0.1492	Time	3884.61279
Sample size	2048	iteration number	961	MSE	0.0723	MAE	0.1608	Time	3963.53125
Sample size	2048	iteration number	971	MSE	0.0729	MAE	0.1620	Time	3945.48296
Sample size	2048	iteration number	981	MSE	0.0714	MAE	0.1572	Time	3912.52684
Sample size	2048	iteration number	991	MSE	0.0764	MAE	0.1628	Time	3890.58160
Sample size	2048	iteration number	1001	MSE	0.0716	MAE	0.1613	Time	3891.57009
Sample size	2048	iteration number	1011	MSE	0.0671	MAE	0.1560	Time	3876.61385
Sample size	2048	iteration number	1021	MSE	0.0733	MAE	0.1601	Time	3915.50278
Sample size	2048	iteration number	1031	MSE	0.0696	MAE	0.1586	Time	3888.60297
Sample size	2048	iteration number	1041	MSE	0.0679	MAE	0.1543	Time	3893.61071
Sample size	2048	iteration number	1051	MSE	0.0678	MAE	0.1549	Time	3884.59062
Sample size	2048	iteration number	1061	MSE	0.0775	MAE	0.1642	Time	3879.65273
Sample size	2048	iteration number	1071	MSE	0.0754	MAE	0.1620	Time	3937.47806
Sample size	2048	iteration number	1081	MSE	0.0695	MAE	0.1613	Time	3972.36132
Sample size	2048	iteration number	1091	MSE	0.0700	MAE	0.1579	Time	3889.60170
Sample size	2048	iteration number	1101	MSE	0.0681	MAE	0.1561	Time	3935.47749
Sample size	2048	iteration number	1111	MSE	0.0723	MAE	0.1588	Time	3882.59124
Sample size	2048	iteration number	1121	MSE	0.0739	MAE	0.1610	Time	3910.54534
Sample size	2048	iteration number	1131	MSE	0.0697	MAE	0.1583	Time	3952.29792
Sample size	2048	iteration number	1141	MSE	0.0639	MAE	0.1507	Time	3976.36795
Sample size	2048	iteration number	1151	MSE	0.0757	MAE	0.1626	Time	3921.16951
Sample size	2048	iteration number	1161	MSE	0.0683	MAE	0.1556	Time	3897.29452
Sample size	2048	iteration number	1171	MSE	0.0716	MAE	0.1556	Time	3876.63912
Sample size	2048	iteration number	1181	MSE	0.0704	MAE	0.1580	Time	3886.60860
Sample size	2048	iteration number	1191	MSE	0.0709	MAE	0.1588	Time	3878.62896
Sample size	2048	iteration number	1201	MSE	0.0694	MAE	0.1611	Time	3915.53115
Sample size	2048	iteration number	1211	MSE	0.0717	MAE	0.1584	Time	3877.65288
Sample size	2048	iteration number	1221	MSE	0.0736	MAE	0.1586	Time	3889.59932
Sample size	2048	iteration number	1231	MSE	0.0674	MAE	0.1551	Time	3883.61406
Sample size	2048	iteration number	1241	MSE	0.0768	MAE	0.1606	Time	3870.65076
Sample size	2048	iteration number	1251	MSE	0.0693	MAE	0.1592	Time	3983.34932
Sample size	2048	iteration number	1261	MSE	0.0674	MAE	0.1543	Time	3963.50359
Sample size	2048	iteration number	1271	MSE	0.0708	MAE	0.1579	Time	3878.62658
Sample size	2048	iteration number	1281	MSE	0.0679	MAE	0.1562	Time	3938.57336
Sample size	2048	iteration number	1291	MSE	0.0699	MAE	0.1573	Time	3947.44014
Sample size	2048	iteration number	1301	MSE	0.0749	MAE	0.1616	Time	3943.45617
Sample size	2048	iteration number	1311	MSE	0.0767	MAE	0.1676	Time	3889.60123
Sample size	2048	iteration number	1321	MSE	0.0743	MAE	0.1640	Time	3958.41622
Sample size	2048	iteration number	1331	MSE	0.0728	MAE	0.1608	Time	3940.50788
Sample size	2048	iteration number	1341	MSE	0.0676	MAE	0.1537	Time	3952.45719
Sample size	2048	iteration number	1351	MSE	0.0669	MAE	0.1547	Time	3893.58925
Sample size	2048	iteration number	1361	MSE	0.0733	MAE	0.1610	Time	3874.63903
Sample size	2048	iteration number	1371	MSE	0.0725	MAE	0.1605	Time	3885.61105

Sample size	2048	iteration number	1381	MSE	0.0693	MAE	0.1585	Time	3913.95664
Sample size	2048	iteration number	1391	MSE	0.0657	MAE	0.1553	Time	3886.60883
Sample size	2048	iteration number	1401	MSE	0.0704	MAE	0.1557	Time	3885.60795
Sample size	2048	iteration number	1411	MSE	0.0702	MAE	0.1591	Time	3886.60812
Sample size	2048	iteration number	1421	MSE	0.0648	MAE	0.1527	Time	3887.57872
Sample size	2048	iteration number	1431	MSE	0.0699	MAE	0.1599	Time	3883.61620
Sample size	2048	iteration number	1441	MSE	0.0697	MAE	0.1561	Time	3912.53900
Sample size	2048	iteration number	1451	MSE	0.0704	MAE	0.1589	Time	3938.62295
Sample size	2048	iteration number	1461	MSE	0.0639	MAE	0.1517	Time	3943.45617
Sample size	2048	iteration number	1471	MSE	0.0723	MAE	0.1601	Time	3893.58902
Sample size	2048	iteration number	1481	MSE	0.0706	MAE	0.1587	Time	3872.64537
Sample size	2048	iteration number	1491	MSE	0.0719	MAE	0.1603	Time	3896.60692
Sample size	2048	iteration number	1501	MSE	0.0695	MAE	0.1569	Time	3917.52672
Sample size	2048	iteration number	1511	MSE	0.0678	MAE	0.1569	Time	3897.57871
Sample size	2048	iteration number	1521	MSE	0.0713	MAE	0.1625	Time	3896.63386
Sample size	2048	iteration number	1531	MSE	0.0693	MAE	0.1585	Time	3890.62976
Sample size	2048	iteration number	1541	MSE	0.0684	MAE	0.1567	Time	3884.64045
Sample size	2048	iteration number	1551	MSE	0.0703	MAE	0.1591	Time	3931.48827
Sample size	2048	iteration number	1561	MSE	0.0683	MAE	0.1536	Time	3917.55199
Sample size	2048	iteration number	1571	MSE	0.0694	MAE	0.1598	Time	3883.61454
Sample size	2048	iteration number	1581	MSE	0.0677	MAE	0.1553	Time	3879.62317
Sample size	2048	iteration number	1591	MSE	0.0729	MAE	0.1601	Time	3874.24421
Sample size	2048	iteration number	1601	MSE	0.0684	MAE	0.1536	Time	3893.52083
Sample size	2048	iteration number	1611	MSE	0.0751	MAE	0.1644	Time	3879.62913
Sample size	2048	iteration number	1621	MSE	0.0747	MAE	0.1621	Time	3911.54122
Sample size	2048	iteration number	1631	MSE	0.0698	MAE	0.1576	Time	3888.60225
Sample size	2048	iteration number	1641	MSE	0.0678	MAE	0.1555	Time	3872.64537
Sample size	2048	iteration number	1651	MSE	0.0683	MAE	0.1547	Time	3889.60695
Sample size	2048	iteration number	1661	MSE	0.0709	MAE	0.1606	Time	3888.62872
Sample size	2048	iteration number	1671	MSE	0.0684	MAE	0.1529	Time	3889.57142
Sample size	2048	iteration number	1681	MSE	0.0717	MAE	0.1571	Time	3926.50318
Sample size	2048	iteration number	1691	MSE	0.0703	MAE	0.1566	Time	3876.62839
Sample size	2048	iteration number	1701	MSE	0.0677	MAE	0.1539	Time	3890.57040
Sample size	2048	iteration number	1711	MSE	0.0716	MAE	0.1587	Time	3919.51870
Sample size	2048	iteration number	1721	MSE	0.0687	MAE	0.1533	Time	3883.61668
Sample size	2048	iteration number	1731	MSE	0.0691	MAE	0.1588	Time	3889.59980
Sample size	2048	iteration number	1741	MSE	0.0661	MAE	0.1553	Time	3937.47139
Sample size	2048	iteration number	1751	MSE	0.0712	MAE	0.1594	Time	3899.59836
Sample size	2048	iteration number	1761	MSE	0.0698	MAE	0.1577	Time	3888.60297
Sample size	2048	iteration number	1771	MSE	0.0681	MAE	0.1524	Time	3883.64338
Sample size	2048	iteration number	1781	MSE	0.0637	MAE	0.1509	Time	3878.74960
Sample size	2048	iteration number	1791	MSE	0.0704	MAE	0.1573	Time	3880.59806
Sample size	2048	iteration number	1801	MSE	0.0702	MAE	0.1558	Time	3910.54415
Sample size	2048	iteration number	1811	MSE	0.0676	MAE	0.1562	Time	3908.52642
Sample size	2048	iteration number	1821	MSE	0.0681	MAE	0.1536	Time	3889.59765
Sample size	2048	iteration number	1831	MSE	0.0690	MAE	0.1554	Time	3891.83855
Sample size	2048	iteration number	1841	MSE	0.0673	MAE	0.1549	Time	3882.59220
Sample size	2048	iteration number	1851	MSE	0.0724	MAE	0.1579	Time	3893.58329

Sample size	2048	iteration number	1861	MSE	0.0677	MAE	0.1533	Time	3926.52726
Sample size	2048	iteration number	1871	MSE	0.0716	MAE	0.1573	Time	3878.65877
Sample size	2048	iteration number	1881	MSE	0.0701	MAE	0.1604	Time	3889.65416
Sample size	2048	iteration number	1891	MSE	0.0734	MAE	0.1593	Time	3905.55238
Sample size	2048	iteration number	1901	MSE	0.0724	MAE	0.1609	Time	3896.58117
Sample size	2048	iteration number	1911	MSE	0.0715	MAE	0.1591	Time	3898.57697
Sample size	2048	iteration number	1921	MSE	0.0722	MAE	0.1636	Time	3950.45709
Sample size	2048	iteration number	1931	MSE	0.0703	MAE	0.1571	Time	3899.58000
Sample size	2048	iteration number	1941	MSE	0.0702	MAE	0.1572	Time	3901.56698
Sample size	2048	iteration number	1951	MSE	0.0732	MAE	0.1636	Time	3932.48605
Sample size	2048	iteration number	1961	MSE	0.0678	MAE	0.1539	Time	3971.73380
Sample size	2048	iteration number	1971	MSE	0.0719	MAE	0.1587	Time	3936.47456
Sample size	2048	iteration number	1981	MSE	0.0715	MAE	0.1587	Time	3990.44323
Sample size	2048	iteration number	1991	MSE	0.0677	MAE	0.1569	Time	3893.80264
Sample size	2048	iteration number	2001	MSE	0.0678	MAE	0.1545	Time	3940.46378
Sample size	2048	iteration number	2011	MSE	0.0688	MAE	0.1541	Time	3928.49612
Sample size	2048	iteration number	2021	MSE	0.0695	MAE	0.1610	Time	3882.62152
Sample size	2048	iteration number	2031	MSE	0.0657	MAE	0.1524	Time	3889.59932
Sample size	2048	iteration number	2041	MSE	0.0678	MAE	0.1511	Time	3913.56396
Sample size	2048	iteration number	2051	MSE	0.0675	MAE	0.1536	Time	3877.60734
Sample size	2048	iteration number	2061	MSE	0.0693	MAE	0.1550	Time	3868.63040
Sample size	2048	iteration number	2071	MSE	0.0661	MAE	0.1534	Time	3881.62231
Sample size	2048	iteration number	2081	MSE	0.0718	MAE	0.1609	Time	3872.64514
Sample size	2048	iteration number	2091	MSE	0.0705	MAE	0.1566	Time	3884.60922
Sample size	2048	iteration number	2101	MSE	0.0727	MAE	0.1614	Time	3904.55627
Sample size	2048	iteration number	2111	MSE	0.0688	MAE	0.1561	Time	3875.66375
Sample size	2048	iteration number	2121	MSE	0.0727	MAE	0.1602	Time	3882.61866
Sample size	2048	iteration number	2131	MSE	0.0719	MAE	0.1626	Time	3931.48803
Sample size	2048	iteration number	2141	MSE	0.0691	MAE	0.1567	Time	3883.64243
Sample size	2048	iteration number	2151	MSE	0.0750	MAE	0.1653	Time	3882.29370
Sample size	2048	iteration number	2161	MSE	0.0704	MAE	0.1594	Time	3907.55271
Sample size	2048	iteration number	2171	MSE	0.0705	MAE	0.1599	Time	3872.65086
Sample size	2048	iteration number	2181	MSE	0.0724	MAE	0.1577	Time	3873.61311
Sample size	2048	iteration number	2191	MSE	0.0673	MAE	0.1567	Time	3976.45759
Sample size	2048	iteration number	2201	MSE	0.0666	MAE	0.1544	Time	3880.62405
Sample size	2048	iteration number	2211	MSE	0.0726	MAE	0.1612	Time	3883.61525
Sample size	2048	iteration number	2221	MSE	0.0713	MAE	0.1559	Time	3922.52087
Sample size	2048	iteration number	2231	MSE	0.0726	MAE	0.1619	Time	3885.63704
Sample size	2048	iteration number	2241	MSE	0.0695	MAE	0.1569	Time	3881.62159
Sample size	2048	iteration number	2251	MSE	0.0721	MAE	0.1585	Time	3879.60100
Sample size	2048	iteration number	2261	MSE	0.0693	MAE	0.1550	Time	3876.63435
Sample size	2048	iteration number	2271	MSE	0.0650	MAE	0.1502	Time	3884.61232
Sample size	2048	iteration number	2281	MSE	0.0692	MAE	0.1556	Time	3902.38142
Sample size	2048	iteration number	2291	MSE	0.0684	MAE	0.1545	Time	3990.33045
Sample size	2048	iteration number	2301	MSE	0.0714	MAE	0.1577	Time	3931.48756
Sample size	2048	iteration number	2311	MSE	0.0722	MAE	0.1578	Time	4041.90659
Sample size	2048	iteration number	2321	MSE	0.0703	MAE	0.1576	Time	4065.58322
Sample size	2048	iteration number	2331	MSE	0.0721	MAE	0.1638	Time	4053.42650

Sample size	2048	iteration number	2341	MSE	0.0679	MAE	0.1563	Time	4026.37052
Sample size	2048	iteration number	2351	MSE	0.0720	MAE	0.1585	Time	4064.58878
Sample size	2048	iteration number	2361	MSE	0.0650	MAE	0.1535	Time	4039.10732
Sample size	2048	iteration number	2371	MSE	0.0697	MAE	0.1578	Time	4036.55266
Sample size	2048	iteration number	2381	MSE	0.0705	MAE	0.1595	Time	4024.19138
Sample size	2048	iteration number	2391	MSE	0.0748	MAE	0.1609	Time	4353.35373
Sample size	2048	iteration number	2401	MSE	0.0642	MAE	0.1482	Time	4096.98510
Sample size	2048	iteration number	2411	MSE	0.0777	MAE	0.1647	Time	4093.86324
Sample size	2048	iteration number	2421	MSE	0.0698	MAE	0.1559	Time	4111.66024
Sample size	2048	iteration number	2431	MSE	0.0673	MAE	0.1548	Time	4107.05566
Sample size	2048	iteration number	2441	MSE	0.0695	MAE	0.1556	Time	4132.15303
Sample size	2048	iteration number	2451	MSE	0.0684	MAE	0.1527	Time	4137.12525
Sample size	2048	iteration number	2461	MSE	0.0674	MAE	0.1516	Time	4086.18092
Sample size	2048	iteration number	2471	MSE	0.0686	MAE	0.1546	Time	4094.00153
Sample size	2048	iteration number	2481	MSE	0.0696	MAE	0.1567	Time	4130.13434
Sample size	2048	iteration number	2491	MSE	0.0686	MAE	0.1600	Time	4108.49905
Sample size	2048	iteration number	2501	MSE	0.0705	MAE	0.1581	Time	4085.07370
Sample size	2048	iteration number	2511	MSE	0.0702	MAE	0.1561	Time	4120.59593
Sample size	2048	iteration number	2521	MSE	0.0669	MAE	0.1534	Time	3925.73452
Sample size	2048	iteration number	2531	MSE	0.0646	MAE	0.1526	Time	4105.36980
Sample size	2048	iteration number	2541	MSE	0.0734	MAE	0.1610	Time	4083.91714
Sample size	2048	iteration number	2551	MSE	0.0686	MAE	0.1578	Time	4257.42244
Sample size	2048	iteration number	2561	MSE	0.0731	MAE	0.1630	Time	4241.88470
Sample size	2048	iteration number	2571	MSE	0.0655	MAE	0.1513	Time	4256.11376
Sample size	2048	iteration number	2581	MSE	0.0685	MAE	0.1562	Time	3942.49153
Sample size	2048	iteration number	2591	MSE	0.0692	MAE	0.1568	Time	3882.61818
Sample size	2048	iteration number	2601	MSE	0.0696	MAE	0.1558	Time	3934.47995
Sample size	2048	iteration number	2611	MSE	0.0670	MAE	0.1532	Time	3886.58189
Sample size	2048	iteration number	2621	MSE	0.0694	MAE	0.1579	Time	3956.44617
Sample size	2048	iteration number	2631	MSE	0.0652	MAE	0.1526	Time	3883.61573
Sample size	2048	iteration number	2641	MSE	0.0698	MAE	0.1572	Time	3937.43825
Sample size	2048	iteration number	2651	MSE	0.0698	MAE	0.1577	Time	3977.36501
Sample size	2048	iteration number	2661	MSE	0.0656	MAE	0.1507	Time	3887.60900
Sample size	2048	iteration number	2671	MSE	0.0712	MAE	0.1596	Time	3890.59734
Sample size	2048	iteration number	2681	MSE	0.0698	MAE	0.1549	Time	3909.54613
Sample size	2048	iteration number	2691	MSE	0.0745	MAE	0.1611	Time	3895.59245
Sample size	2048	iteration number	2701	MSE	0.0658	MAE	0.1539	Time	3879.62508
Sample size	2048	iteration number	2711	MSE	0.0687	MAE	0.1546	Time	3886.63339
Sample size	2048	iteration number	2721	MSE	0.0703	MAE	0.1562	Time	3891.59464
Sample size	2048	iteration number	2731	MSE	0.0692	MAE	0.1553	Time	3891.62969
Sample size	2048	iteration number	2741	MSE	0.0698	MAE	0.1575	Time	3966.39442
Sample size	2048	iteration number	2751	MSE	0.0703	MAE	0.1579	Time	3893.59641
Sample size	2048	iteration number	2761	MSE	0.0682	MAE	0.1549	Time	3922.60909
Sample size	2048	iteration number	2771	MSE	0.0724	MAE	0.1592	Time	3942.46792
Sample size	2048	iteration number	2781	MSE	0.0698	MAE	0.1549	Time	3881.62088
Sample size	2048	iteration number	2791	MSE	0.0695	MAE	0.1537	Time	3883.58974
Sample size	2048	iteration number	2801	MSE	0.0678	MAE	0.1542	Time	3929.46648
Sample size	2048	iteration number	2811	MSE	0.0687	MAE	0.1576	Time	3897.60398

Sample size	2048	iteration number	2821	MSE	0.0719	MAE	0.1568	Time	3893.61548
Sample size	2048	iteration number	2831	MSE	0.0693	MAE	0.1589	Time	3884.61327
Sample size	2048	iteration number	2841	MSE	0.0696	MAE	0.1556	Time	3886.60740
Sample size	2048	iteration number	2851	MSE	0.0683	MAE	0.1557	Time	3888.63349
Sample size	2048	iteration number	2861	MSE	0.0670	MAE	0.1523	Time	3910.54368
Sample size	2048	iteration number	2871	MSE	0.0700	MAE	0.1593	Time	3898.57626
Sample size	2048	iteration number	2881	MSE	0.0697	MAE	0.1553	Time	3901.59416
Sample size	2048	iteration number	2891	MSE	0.0732	MAE	0.1629	Time	3944.48518
Sample size	2048	iteration number	2901	MSE	0.0677	MAE	0.1559	Time	3899.57332
Sample size	2048	iteration number	2911	MSE	0.0723	MAE	0.1625	Time	4135.21504
Sample size	2048	iteration number	2921	MSE	0.0684	MAE	0.1557	Time	3989.37535
Sample size	2048	iteration number	2931	MSE	0.0666	MAE	0.1532	Time	4119.14968
Sample size	2048	iteration number	2941	MSE	0.0724	MAE	0.1615	Time	4095.81255
Sample size	2048	iteration number	2951	MSE	0.0669	MAE	0.1545	Time	4101.24087
Sample size	2048	iteration number	2961	MSE	0.0722	MAE	0.1599	Time	4092.58675
Sample size	2048	iteration number	2971	MSE	0.0715	MAE	0.1596	Time	4096.98867
Sample size	2048	iteration number	2981	MSE	0.0676	MAE	0.1548	Time	4090.28124
Sample size	2048	iteration number	2991	MSE	0.0684	MAE	0.1535	Time	4109.17139
Sample size	2048	iteration number	3001	MSE	0.0679	MAE	0.1550	Time	4102.31471
Sample size	2048	iteration number	3011	MSE	0.0679	MAE	0.1578	Time	3887.57991
Sample size	2048	iteration number	3021	MSE	0.0711	MAE	0.1601	Time	4017.30752
Sample size	2048	iteration number	3031	MSE	0.0677	MAE	0.1503	Time	3880.62286
Sample size	2048	iteration number	3041	MSE	0.0667	MAE	0.1552	Time	4028.96380
Sample size	2048	iteration number	3051	MSE	0.0773	MAE	0.1635	Time	3877.74300
Sample size	2048	iteration number	3061	MSE	0.0672	MAE	0.1542	Time	3915.55523
Sample size	2048	iteration number	3071	MSE	0.0732	MAE	0.1588	Time	4268.48936
Sample size	2048	iteration number	3081	MSE	0.0673	MAE	0.1549	Time	4032.30357
Sample size	2048	iteration number	3091	MSE	0.0682	MAE	0.1550	Time	4138.67020
Sample size	2048	iteration number	3101	MSE	0.0712	MAE	0.1584	Time	4066.47539
Sample size	2048	iteration number	3111	MSE	0.0677	MAE	0.1528	Time	4054.27575
Sample size	2048	iteration number	3121	MSE	0.0675	MAE	0.1548	Time	4039.10398
Sample size	2048	iteration number	3131	MSE	0.0693	MAE	0.1558	Time	4033.20789
Sample size	2048	iteration number	3141	MSE	0.0657	MAE	0.1530	Time	4143.47362
Sample size	2048	iteration number	3151	MSE	0.0653	MAE	0.1509	Time	4038.28907
Sample size	2048	iteration number	3161	MSE	0.0710	MAE	0.1557	Time	4027.18281
Sample size	2048	iteration number	3171	MSE	0.0666	MAE	0.1521	Time	4056.67018
Sample size	2048	iteration number	3181	MSE	0.0728	MAE	0.1585	Time	4045.62974
Sample size	2048	iteration number	3191	MSE	0.0694	MAE	0.1553	Time	4042.36817
Sample size	2048	iteration number	3201	MSE	0.0680	MAE	0.1568	Time	4034.22427
Sample size	2048	iteration number	3211	MSE	0.0671	MAE	0.1549	Time	4049.21531
Sample size	2048	iteration number	3221	MSE	0.0694	MAE	0.1594	Time	4035.72797
Sample size	2048	iteration number	3231	MSE	0.0667	MAE	0.1530	Time	4142.62509
Sample size	2048	iteration number	3241	MSE	0.0709	MAE	0.1587	Time	4039.33620
Sample size	2048	iteration number	3251	MSE	0.0647	MAE	0.1546	Time	3980.16905
Sample size	2048	iteration number	3261	MSE	0.0665	MAE	0.1533	Time	3970.35861
Sample size	2048	iteration number	3271	MSE	0.0663	MAE	0.1524	Time	3878.79562
Sample size	2048	iteration number	3281	MSE	0.0641	MAE	0.1547	Time	3874.92847
Sample size	2048	iteration number	3291	MSE	0.0707	MAE	0.1546	Time	3880.05733

Sample size	2048	iteration number	3301	MSE	0.0720	MAE	0.1592	Time	3875.71811
Sample size	2048	iteration number	3311	MSE	0.0698	MAE	0.1572	Time	3905.09700
Sample size	2048	iteration number	3321	MSE	0.0665	MAE	0.1521	Time	3932.74307
Sample size	2048	iteration number	3331	MSE	0.0685	MAE	0.1547	Time	3876.48344
Sample size	2048	iteration number	3341	MSE	0.0689	MAE	0.1533	Time	3877.70938
Sample size	2048	iteration number	3351	MSE	0.0726	MAE	0.1585	Time	3874.33362
Sample size	2048	iteration number	3361	MSE	0.0687	MAE	0.1577	Time	3865.96560
Sample size	2048	iteration number	3371	MSE	0.0668	MAE	0.1535	Time	3910.33554
Sample size	2048	iteration number	3381	MSE	0.0669	MAE	0.1547	Time	3877.59137
Sample size	2048	iteration number	3391	MSE	0.0674	MAE	0.1544	Time	3903.38778
Sample size	2048	iteration number	3401	MSE	0.0718	MAE	0.1604	Time	3880.84197
Sample size	2048	iteration number	3411	MSE	0.0669	MAE	0.1510	Time	3874.02057
Sample size	2048	iteration number	3421	MSE	0.0693	MAE	0.1564	Time	3870.79858
Sample size	2048	iteration number	3431	MSE	0.0670	MAE	0.1522	Time	3928.92313
Sample size	2048	iteration number	3441	MSE	0.0689	MAE	0.1548	Time	3874.09138
Sample size	2048	iteration number	3451	MSE	0.0680	MAE	0.1549	Time	3879.70638
Sample size	2048	iteration number	3461	MSE	0.0663	MAE	0.1524	Time	3862.18166
Sample size	2048	iteration number	3471	MSE	0.0688	MAE	0.1581	Time	3861.10186
Sample size	2048	iteration number	3481	MSE	0.0725	MAE	0.1597	Time	3878.68833
Sample size	2048	iteration number	3491	MSE	0.0653	MAE	0.1533	Time	3891.85285
Sample size	2048	iteration number	3501	MSE	0.0704	MAE	0.1580	Time	3880.26714
Sample size	2048	iteration number	3511	MSE	0.0714	MAE	0.1580	Time	3862.25700
Sample size	2048	iteration number	3521	MSE	0.0672	MAE	0.1541	Time	3877.61616
Sample size	2048	iteration number	3531	MSE	0.0726	MAE	0.1615	Time	3880.67603
Sample size	2048	iteration number	3541	MSE	0.0699	MAE	0.1623	Time	3883.42905
Sample size	2048	iteration number	3551	MSE	0.0733	MAE	0.1609	Time	3911.76819
Sample size	2048	iteration number	3561	MSE	0.0751	MAE	0.1620	Time	3879.99343
Sample size	2048	iteration number	3571	MSE	0.0677	MAE	0.1546	Time	3890.60998
Sample size	2048	iteration number	3581	MSE	0.0723	MAE	0.1594	Time	3876.35016
Sample size	2048	iteration number	3591	MSE	0.0702	MAE	0.1551	Time	3865.44466
Sample size	2048	iteration number	3601	MSE	0.0690	MAE	0.1585	Time	3882.66277
Sample size	2048	iteration number	3611	MSE	0.0733	MAE	0.1598	Time	3908.61916
Sample size	2048	iteration number	3621	MSE	0.0668	MAE	0.1538	Time	3869.57192
Sample size	2048	iteration number	3631	MSE	0.0692	MAE	0.1563	Time	3888.22484
Sample size	2048	iteration number	3641	MSE	0.0697	MAE	0.1573	Time	3879.26268
Sample size	2048	iteration number	3651	MSE	0.0766	MAE	0.1612	Time	3871.87814
Sample size	2048	iteration number	3661	MSE	0.0680	MAE	0.1529	Time	3871.82974
Sample size	2048	iteration number	3671	MSE	0.0733	MAE	0.1584	Time	3907.68170
Sample size	2048	iteration number	3681	MSE	0.0651	MAE	0.1523	Time	3857.34343
Sample size	2048	iteration number	3691	MSE	0.0666	MAE	0.1521	Time	3882.84850
Sample size	2048	iteration number	3701	MSE	0.0646	MAE	0.1523	Time	3873.66628
Sample size	2048	iteration number	3711	MSE	0.0672	MAE	0.1543	Time	3864.11500
Sample size	2048	iteration number	3721	MSE	0.0687	MAE	0.1569	Time	3867.83838
Sample size	2048	iteration number	3731	MSE	0.0696	MAE	0.1583	Time	3914.68882
Sample size	2048	iteration number	3741	MSE	0.0688	MAE	0.1552	Time	4005.04946
Sample size	2048	iteration number	3751	MSE	0.0707	MAE	0.1581	Time	4087.83578
Sample size	2048	iteration number	3761	MSE	0.0684	MAE	0.1569	Time	4093.93286
Sample size	2048	iteration number	3771	MSE	0.0692	MAE	0.1558	Time	4130.62882

Sample size	2048	iteration number	3781	MSE	0.0663	MAE	0.1566	Time	3871.76990
Sample size	2048	iteration number	3791	MSE	0.0656	MAE	0.1550	Time	3879.93645
Sample size	2048	iteration number	3801	MSE	0.0670	MAE	0.1534	Time	3884.59229
Sample size	2048	iteration number	3811	MSE	0.0691	MAE	0.1557	Time	3905.32040
Sample size	2048	iteration number	3821	MSE	0.0657	MAE	0.1507	Time	3877.22444
Sample size	2048	iteration number	3831	MSE	0.0698	MAE	0.1582	Time	3878.99065
Sample size	2048	iteration number	3841	MSE	0.0653	MAE	0.1497	Time	3872.36070
Sample size	2048	iteration number	3851	MSE	0.0633	MAE	0.1498	Time	3880.48505
Sample size	2048	iteration number	3861	MSE	0.0680	MAE	0.1548	Time	3927.10375
Sample size	2048	iteration number	3871	MSE	0.0652	MAE	0.1524	Time	3875.70118
Sample size	2048	iteration number	3881	MSE	0.0681	MAE	0.1561	Time	3877.43282
Sample size	2048	iteration number	3891	MSE	0.0684	MAE	0.1564	Time	3871.44708
Sample size	2048	iteration number	3901	MSE	0.0675	MAE	0.1510	Time	3873.37303
Sample size	2048	iteration number	3911	MSE	0.0709	MAE	0.1588	Time	3875.72932
Sample size	2048	iteration number	3921	MSE	0.0655	MAE	0.1507	Time	3882.09891
Sample size	2048	iteration number	3931	MSE	0.0725	MAE	0.1613	Time	3857.98263
Sample size	2048	iteration number	3941	MSE	0.0706	MAE	0.1553	Time	3860.10909
Sample size	2048	iteration number	3951	MSE	0.0645	MAE	0.1512	Time	3863.88325
Sample size	2048	iteration number	3961	MSE	0.0746	MAE	0.1613	Time	3857.73158
Sample size	2048	iteration number	3971	MSE	0.0649	MAE	0.1515	Time	3872.85971
Sample size	2048	iteration number	3981	MSE	0.0706	MAE	0.1586	Time	3877.62188
Sample size	2048	iteration number	3991	MSE	0.0702	MAE	0.1582	Time	3877.97164
Sample size	2048	iteration number	4001	MSE	0.0691	MAE	0.1590	Time	3872.98607

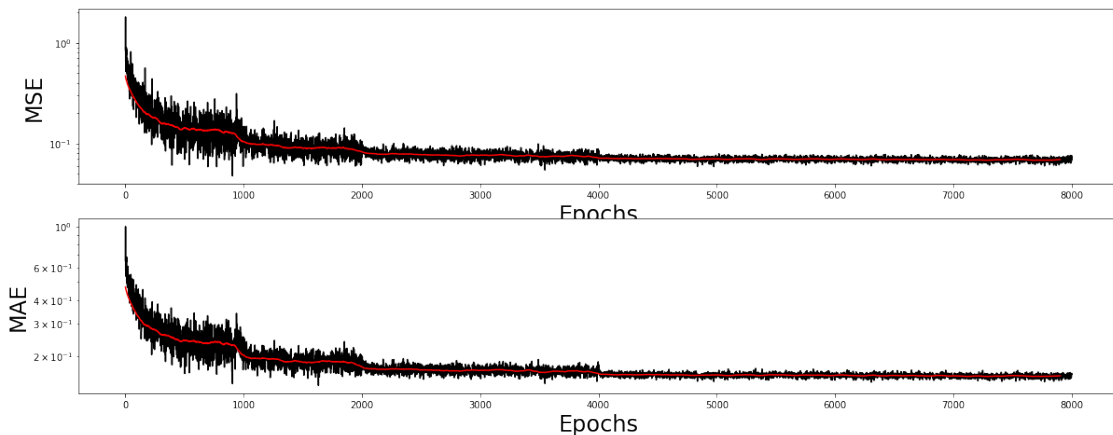
1.6 6. PLOT LEARNING PERFORMANCE

The learning performance is plotted. The MSE, MAE, sample size, iteration number and iteration time are plotted against the number of timesteps.

Comment: 1. The parameter `number_of_timesteps_for_average` determines the length of the average. It must be a positive integer number.

```
In [8]: ### Plot learning performance
        number_of_timesteps_for_average = 100
```

```
DeepCalib.plot_learning_performance(training_history, number_of_timesteps_for_average)
```

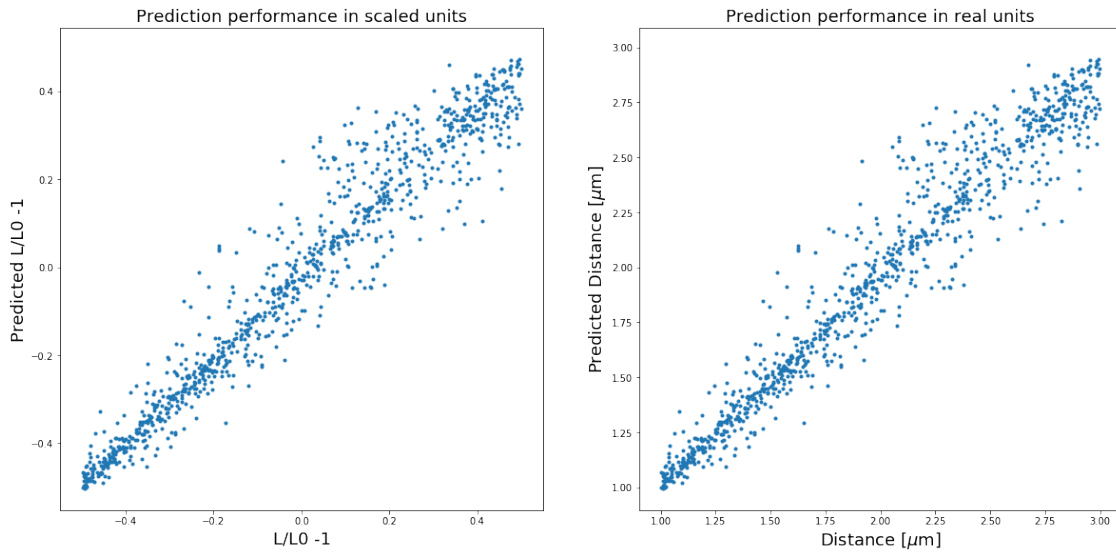


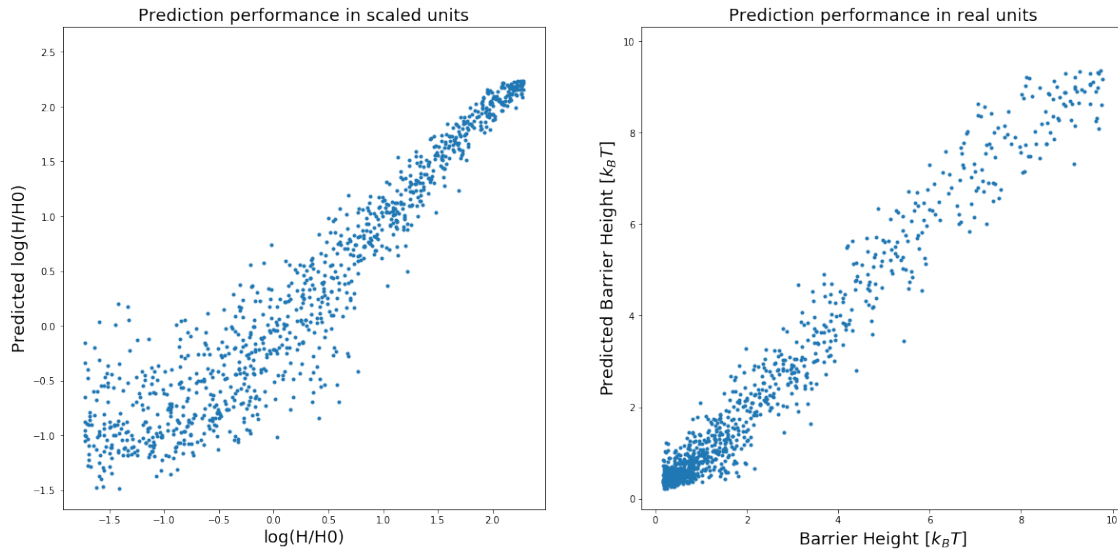
1.7 7. TEST DEEP LEARNING NETWORK ON NEW SIMULATED TRAJECTORIES

The deep learning network is tested on new simulated trajectories (parameters are defined in Section ??). The predicted values of the targets are plotted as function of their ground-truth values both in scaled and physical units.

Comments: 1. The parameter `number_of_predictions_to_show` determines the number of predictions that are shown.

```
In [9]: ### Test the predictions of the deep learning network on some generated trajectories  
        number_of_predictions_to_show = 1000  
  
        %matplotlib inline  
        DeepCalib.plot_test_performance(simulate_trajectory, network, rescale_targets, number_of
```





1.8 9. SAVE DEEP LEARNING NETWORK

Comments: 1. The parameter `save_file_name` is the name of the file where the deep learning network is saved. 2. By default, the network is saved in the same folder where DeepCalib is running.

```
In [10]: save_file_name = 'Network_Example_2a.h5'
         network.save(save_file_name)
```